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INDUSTRIAL CODE

PROPOSED RULES

FOR THE

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Construction, Installation, Inspection and Maintenance of Steam Boilers

STATE OF NEW YORK

DEPARTMENT OF LABOR STATE INDUSTRIAL COMMISSION

ALBANY

NEW YORK OFFICE, 230 FIFTH AVENUE

BUREAU OF INDUSTRIAL CODE

230 Fifth Avenue, New York City

PUBLIC HEARINGS WILL BE HELD AS FOLLOWS:

BUFFALO

Monday, April 9th, 10:00 A. M.
Room 225, Chamber of Commerce

ROCHESTER

Tuesday, April 10th, 10:00 A. M.
Chamber of Commerce

SYRACUSE

Wednesday, April 11th, 10:00 A. M.
City Hall

UTICA

Thursday, April 12th, 9:30 A. M.
Chamber of Commerce

ALBANY

Friday, April 13th, 10:00 A. M.
Chamber of Commerce, Arkay Building

NEW YORK CITY

Tuesday, April 17th, 10:00 A. M.
Bureau of Industrial Code,
230 Fifth Ave., Room 2015

Copies of these proposed rules can be had by applying to the Bureau of Industrial Code,
230 Fifth Avenue, New York City.

621.185

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BOILER CODE

STATE INDUSTRIAL COMMISSION

Rules for the construction, installation, inspection and maintenance of steam boilers as provided in sections 91 and 124 of the Labor Law.

Section 91. Boiler inspection. The commissioner of labor shall cause to be inspected all boilers used for generating steam or heat for factory purposes which carry a steam pressure of ten pounds or more to the square inch, except where a certificate is filed with such commissioner, or shall have been heretofore filed with the state fire marshal under the provisions of former section three hundred and fifty-seven of the insurance law, by a duly authorized insurance company, in conformity with the rules or regulations of the officer with whom such certificate shall have been filed, and certifying that upon such inspection such boilers have been found to be in a safe condition. Every such insurance company shall report to the commissioner all boilers insured by them coming within the provisions of this section including those rejected, together with the reason therefor. A fee of five dollars shall be charged the owner or lessee of each boiler inspected by the inspector of the department of labor, but not more than the sum of ten dollars shall be collected for the inspection of any one boiler for any year. Such fee shall be payable within thirty days from the date of such inspection. If a certificate of inspection, heretofore filed in the office of the state fire marshal, or hereafter filed in the office of the commissioner of labor shows a boiler to be in need of repairs or in an unsafe or dangerous condition, the commissioner of labor shall order such repairs to be made to such boiler as in his judgment may be necessary and he shall order the use of such boiler discontinued until such repairs are made or such dangerous and unsafe conditions remedied. Such order shall be served upon the owner or lessee of the boiler, personally or by mail, and any owner or lessee failing to comply with such order within a time to be specified therein, which shall be not less than ten days from the service of the order if served personally and not less than fifteen days from the mailing thereof if served by mail, shall be liable to a penalty of fifty dollars for each day's neglect thereafter. Every owner or lessee of any such boiler who shall use or allow a boiler to be used by any one in his employ after receiving notice that such boiler is in an unsafe or dangerous condition shall be subject to a penalty of not to exceed five dollars for each day on which such boiler is used after the receipt of such notice. Owners and lessees of boilers shall attach to such boilers the numbers assigned by the commis-

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sioner of labor, under a penalty of five dollars for each day's failure so to do after such numbers have been assigned.

The provisions of this section shall not apply to cities in which boilers are regularly inspected by competent inspectors acting under the authority of local laws or ordinances.

§ 124. Inspection of steam boilers and apparatus; steam, air and water gauges. All boilers used in generating steam for mining or tunneling purposes shall be kept in good order, and the owner, agent, manager or lessee of such mine or tunnel shall have such boilers inspected by a competent person, approved by the commissioner of labor, once in six months, and shall file a certificate showing the result thereof in the mine or tunnel office and a duplicate thereof in the office of the commissioner of labor. * * * Each boiler or battery of boilers used in mining or tunneling for generating steam, shall be provided with a proper safety valve and with steam and water gauges, to show respectively, the pressure of steam and the height of water in the boilers. Every boiler-house in which a boiler or nest of boilers is placed, shall be provided with steam gauge properly connected with the boilers, and another steam gauge shall be attached to the steam pipe in the engine-house, and so placed that the engineer or fireman can readily ascertain the pressure carried.

Rule 800. All boilers used for generating steam or heat for factory purposes, shall be subject to a regular internal and external inspection each year, and all boilers used for generating steam or heat for mining, tunneling and quarrying purposes, shall be inspected externally at least once in six months and subject to a regular internal inspection each year.

Rule 801. Whoever owns, uses or causes to be used a portable boiler subject to inspection, as provided in sections 91 and 124 of the Labor Law, shall report the location of such boilers to the Industrial Commission on January first, or within thirty days thereafter, of each year.

Rule 802. The owner or user of a boiler or boilers herein required to be inspected shall, after fifteen days notice, prepare the boiler for internal inspection, or hydrostatic pressure test, if necessary. To prepare a boiler for internal inspection, the water shall be drawn off and the boiler thoroughly washed. All manhole and handhole covers, and washout plugs in boilers and water column connection shall be removed, and the furnace and combustion chambers thoroughly cooled and cleaned. Enough of the brick work shall be removed to determine the condition of the boiler, furnace or other parts, at each annual inspection, if necessary. The steam gauge shall be removed for testing.

Rule 803. If it is found that steam or hot water is leaking into the boiler, the source of such leakage shall be disconnected and so drained as to cut out such steam or hot water from the boiler to be inspected.

Rule 804. If the boiler is jacketed so that the longitudinal seams of shells, drums or domes, cannot be seen, and if it cannot otherwise be determined, enough of the jacketing, setting wall or other covering shall be removed so that the size and pitch of the rivets and such other data as may be necessary can be determined at first data inspection.

Rule 805. In preparing a boiler for hydrostatic test, the boiler shall be filled to the stop valve. If boiler to be tested is connected with other boilers, that are under steam pressure, such connections shall be blanked off unless there be double stop valves on all connecting pipes, with an open drain between.

INSPECTION BY INSURANCE COMPANY

Rule 806. All boilers subject to periodic inspection by duly authorized insurance companies shall be exempt from regular annual inspection by the Industrial Commission on the following conditions:

- a. The insurance companies' regulations shall conform with these Rules.
- b. The insurance companies' inspectors who inspect boilers operated in this state shall hold certificates of competency issued by the Industrial Commission, as hereinafter provided.
- c. Reports of all inspections shall conform to the requirements, and shall be made upon forms approved by the Commission.
- d. A copy of all internal and external inspection reports shall be filed with the Commission within twenty-one days after the inspection is made.
- e. Insurance companies, whose inspectors hold certificates of competency, shall immediately report to this Commission the name of the owner or user, and the location of every boiler on which insurance has been refused, cancelled or discontinued because of existing dangerous defects and shall within a reasonable time report all other refusals, cancellations or discontinuances.

CERTIFICATE OF COMPETENCY

Rule 807. Certificates of competency and commissions as inspectors of steam boilers shall be issued to persons in the employ of duly authorized boiler insurance companies who pass a written examination as to their knowledge of the construction, installation, maintenance and repair of steam boilers and their appurtenances.

Provided, however, that a person holding a certificate of competency as an inspector of steam boilers for a state that has a standard of examination equal to the standard set by the Industrial Commission of the State of New York, shall, upon written request of a duly authorized boiler insurance company, by whom such person is employed, be granted a certificate of competency and a commission as an inspector of steam boilers for the State of New York without further examination. The commission shall be retained by the insurance company and shall be immediately returned to the Industrial Commission when the inspector ceases to be employed by the said company. Inspectors' certificate shall be issued by the Industrial Commission upon recommendation of an examining board appointed by the Industrial Commission, composed of one representative of each of the following interests: a representative of boiler manufacturers, the duly authorized boiler insurance companies, the operating engineers, the Boiler Inspection Division of the Industrial Commission, and such others as the Industrial Commission may designate.

Rule 808. An applicant who fails to pass an examination shall not be granted a new examination until after the expiration of ninety days.

GENERAL

Rule 809. A certificate of inspection upon the form approved by the Industrial Commission shall be issued and shall be conspicuously posted under glass in the engine or boiler room.

Rule 810. In case a defect affecting the safety of a steam boiler is discovered, the owner or user of the boiler shall immediately discontinue the boiler from service and notify the Industrial Commission. An inspection shall be made and a certificate of inspection issued before the boiler is again placed in service.

Rule 811. Any boiler in this state at the time these rules take effect, if hereafter installed, may be operated after a thorough internal and external inspection and a hydrostatic pressure test and a certificate issued. The maximum allowable working pressure on such boiler shall be determined as provided in Par. 378, Rule 850.

Rule 812. No boiler shall be operated at a pressure in excess of the safe working pressure allowed by the annual inspection certificate, which pressure is to be ascertained by means of these rules.

Rule 813. No person shall remove or tamper with any safety appliance prescribed by these rules, and no person shall in any manner load the safety valve to greater pressure than that allowed by the certificate of inspection.

Rule 814. If there are valves in the connections between water column and boiler, at least one steam gage shall be connected directly

to steam space of boiler, with but one cock between said gage and boiler.

Rule 815. The discharge of safety valves, blow-off pipes, or other outlets, shall be so located that there will be no danger from scalding.

Rule 816. Safety valves, try cocks, water column and water blow-offs on boilers, operated at a pressure of more than fifteen (15) pounds to the square inch, shall be tested daily when the boiler is in operation.

Rule 817. All patches on a boiler shell or drum, which exceed twenty-four inches in length, measured on a line parallel to the longitudinal seam, and between the center lines of the extreme rivet holes, shall be calculated for safe working pressure from said patch seam, the efficiency of which shall be determined in the usual manner. The efficiency of the patch seam may then be increased by multiplying said efficiency by a factor which is determined by the angularity of the inclined patch seam to the girth seam, according to the following table:

Angle	Factor	Angle	Factor
30 degrees.....	1.51	50 degrees.....	1.20
35 ".....	1.42	55 ".....	1.15
40 ".....	1.34	60 ".....	1.11
45 ".....	1.27	65 ".....	1.08

Rule 818. A table of areas of grate surfaces, in square feet for other than direct spring-loaded safety valves, follows:

Maximum Pressure Allowed Per Square Inch on the Boiler		Zero to 25 Lbs.	Over 25 to 50 Lbs.	Over 50 to 100 Lbs.
Diameter of Valve, in Inches	Area of Valve, in Square Inches	Area of Grate, in Square Feet		
1	.7854	1.50	1.75	2.00
1½	1.2272	2.25	2.50	3.00
1¾	1.7671	3.00	3.75	4.00
2	3.1416	5.50	6.50	7.25
2½	4.9087	8.25	10.00	11.00
3	7.0686	11.75	14.25	16.00
3½	9.6211	16.00	19.50	21.75
4	12.5660	21.00	25.50	28.25
4½	15.9040	26.75	32.50	36.00
5	19.6350	32.75	40.00	44.00

Rule 819. A table of areas of grate surfaces, in square feet, for direct spring-loaded safety valves, follows:

		W= 75 3600 P= 40 A=.401	W= 100 3600 P= 65 A=.329	W= 160 3600 P= 115 A=.297	W= 160 3600 P= 140 A=.244	W= 200 3600 P= 190 A=.224	W= 240 3600 P= 240 A=.213
Maximum Pressure allowed per Square Inch on the Boiler		Zero to 25 Pounds	Over 25 to 50 Pounds	Over 50 to 100 Pounds	Over 100 to 150 Pounds	Over 150 to 200 Pounds	Over 200 Pounds
Diameter of Valve, in Inches	Area of Valve, in Square Inches	Area of Grate, in Square Feet					
1	.7854	2.00	2.50	2.75	3.25	3.5	3.75
1½	1.2272	3.25	4.00	4.25	5.00	5.5	5.75
1½	1.7671	4.50	5.50	6.00	7.25	8.0	8.50
2	3.1416	8.00	9.75	10.75	13.00	14.0	15.00
2½	4.9087	12.50	15.00	16.50	20.00	22.0	23.00
3	7.0686	17.75	21.50	24.00	29.00	31.5	33.25
3½	9.6211	24.00	29.50	32.50	39.50	43.0	45.25
4	12.5660	31.50	38.25	42.50	51.50	56.0	59.00
4½	15.9040	40.00	48.50	53.50	65.00	71.0	74.25
5	19.6350	49.00	60.00	66.00	80.00	88.0	92.25

Rule 820. When the conditions exceed those on which the table (Rule 819) is based, the following formula shall be used:

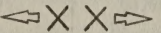
$$A = \frac{W}{P} \times 11.$$

A = Area of direct spring-loaded safety-valve in square inches per square foot of grate surface.

W = Weight of water in pounds evaporated per square foot of grate surface per second.

P = Pressure (absolute) at which the safety valve is set to blow.

If more than one safety valve is used, the minimum combined area shall be in accordance with the table.

Rule 821. All boilers declared unsafe and condemned after an inspection by the chief boiler inspector, shall be designated by XX, with an arrow head on each side, as shown by the following facsimile , stamped thereon.

NEW INSTALLATIONS

PART I—SECTION I

POWER BOILERS

(Paragraphs 1 to 334, inclusive, shall become effective six months after the adoption of these rules.)

RULE 850

SELECTION OF MATERIALS

1 Specifications are given in these Rules for the important materials used in the construction of boilers, and where given, the materials shall conform thereto.

2 Steel plates for any part of a boiler when exposed to the fire or products of combustion, and under pressure, shall be of firebox quality as designated in the Specifications for Boiler Plate Steel.

3 Steel plates for any part of a boiler, where firebox quality is not specified, when under pressure, shall be of firebox or flange quality as designated in the Specifications for Boiler Plate Steel.

4 Braces when welded, shall be of wrought-iron of the quality designated in the Specifications for Refined Wrought-Iron Bars.

5 Manhole and handhole covers and other parts subjected to pressure and braces and lugs, when made of steel plate, shall be of firebox or flange quality as designated in the Specifications for Boiler Plate Steel.

6 Steel bars for braces and for other boiler parts, except as otherwise specified herein, shall be of the quality designated in the Specifications for Steel Bars.

7 Staybolts shall be of iron or steel of the quality designated in the Specifications for Staybolt Iron or in the Specifications for Staybolt Steel.

8 Rivets shall be of steel or iron of the quality designated in the Specifications for Boiler Rivet Steel or in the Specifications for Boiler Rivet Iron.

9 Cross pipes connecting the steam and water drums of water-tube boilers, headers and cross boxes and all pressure parts of the boiler proper over 2-in. pipe size, or equivalent cross-sectional area, shall be of wrought steel, or cast steel of Class B grade, as designated in the Specifications for Steel Castings, when the maximum allowable working pressure exceeds 160 lb. per sq. in.

10 Mud drums of boilers used for other than heating purposes shall be of wrought steel, or cast steel of Class B grade, as designated in the Specifications for Steel Castings.

11 Pressure parts of superheaters, separately fired or attached to stationary boilers, unless of the locomotive type, shall be of wrought steel, or cast steel of Class B grade, as designated in the Specifications for Steel Castings.

12 Cast iron shall not be used for boiler and superheater mountings, such as nozzles, connecting pipes, fittings, valves and their bonnets, for steam temperatures of over 450 deg. fahr.

13 Water-leg and door-frame rings of vertical fire-tube boilers 36 in. or over in diameter, and of locomotive and other type boilers, shall be of wrought iron or steel, or cast steel of Class B grade, as designated in the Specifications for Steel Castings. The O G or other flanged construction may be used as a substitute in any case.

ULTIMATE STRENGTH OF MATERIAL USED IN COMPUTING JOINTS

14 *Tensile Strength of Steel Plate.* The tensile strength used in the computations for steel plates shall be that stamped on the plates as herein provided, which is the minimum of the stipulated range, or 55,000 lbs. per sq. in. for all steel plates, except for special grades having a lower tensile strength.

15 *Crushing Strength of Steel Plate.* The resistance to crushing of steel plate shall be taken at 95,000 lb. per sq. in. of cross-sectional area.

16 *Strength of Rivets in Shear.* In computing the ultimate

strength of rivets in shear, the following values in pounds per square inch of the cross-sectional area of the rivet shank shall be used:

Iron rivets in single shear.....	38,000
Iron rivets in double shear.....	76,000
Steel rivets in single shear.....	44,000
Steel rivets in double shear.....	88,000

The cross-sectional area used in the computations shall be that of the rivet shank after driving.

MINIMUM THICKNESSES OF PLATES AND TUBES

17 *Thickness of Plates.* The minimum thickness of any boiler plate under pressure shall be $\frac{1}{4}$ in.

18 The minimum thicknesses of shell plates, and dome plates after flanging, shall be as follows:

WHEN THE DIAMETER OF SHELL IS

36 In. or Under	Over 36 In. to 54 In.	Over 54 In. to 72 In.	Over 72 In.
$\frac{1}{4}$ in.	$\frac{5}{16}$ in.	$\frac{3}{8}$ in.	$\frac{1}{2}$ in.

19 The minimum thicknesses of butt straps shall be as given in Table 1.

TABLE 1 MINIMUM THICKNESSES OF BUTT STRAPS

Thickness of Shell Plates, In.	Minimum Thickness of Butt Straps, In.	Thickness of Shell Plates, In.	Minimum Thickness of Butt Straps, In.
$\frac{1}{4}$	$\frac{1}{4}$	$\frac{11}{16}$	$\frac{11}{16}$
$\frac{5}{16}$	$\frac{1}{4}$	$\frac{11}{16}$	$\frac{11}{16}$
$\frac{3}{8}$	$\frac{1}{4}$	$\frac{5}{8}$	$\frac{1}{2}$
$\frac{1}{2}$	$\frac{1}{4}$	$\frac{3}{4}$	$\frac{1}{2}$
$\frac{5}{8}$	$\frac{3}{8}$	$\frac{3}{4}$	$\frac{3}{8}$
$\frac{3}{4}$	$\frac{3}{8}$	1	$\frac{3}{4}$
$\frac{7}{8}$	$\frac{3}{8}$	$1\frac{1}{8}$	$\frac{3}{4}$
1	$\frac{3}{8}$	$1\frac{1}{4}$	$\frac{3}{4}$

20 The minimum thicknesses of tube sheets for horizontal return tubular boilers, shall be as follows:

WHEN THE DIAMETER OF TUBE SHEET IS

42 In. or Under	Over 42 In. to 54 In.	Over 54 In. to 72 In.	Over 72 In.
$\frac{3}{8}$ in.	$\frac{7}{16}$ in.	$\frac{1}{2}$ in.	$\frac{9}{16}$ in.

21 *Tubes for Water-Tube Boilers.* The minimum thicknesses of tubes used in water-tube boilers measured by Birmingham wire gage, for maximum allowable working pressures not exceeding 165 lb. per sq. in., shall be as follows:

Diameters less than 3 in.....	No. 12 B.W.G.
Diameter 3 in. or over, but less than 4 in.....	No. 11 B.W.G.
Diameter 4 in. or over, but less than 5 in.....	No. 10 B.W.G.
Diameter 5 in.....	No. 9 B.W.G.

The above thicknesses shall be increased for maximum allowable working pressures higher than 165 lb. per sq. in. as follows:

Over 165 lb. but not exceeding 235 lb.....	1 gage
Over 235 lb. but not exceeding 285 lb.....	2 gages
Over 285 lb. but not exceeding 400 lb.....	3 gages

Tubes over 4-in. diameter shall not be used for maximum allowable working pressures above 285 lb. per sq. in.

22 *Tubes for Fire-Tube Boilers.* The minimum thicknesses of tubes used in fire tube boilers measured by Birmingham wire gage, for maximum allowable working pressures not exceeding 175 lb. per sq. in., shall be as follows:

Diameters less than 2½ in.....	No. 13 B.W.G.
Diameter 2½ in. or over, but less than 3¼ in.....	No. 12 B.W.G.
Diameter 3¼ in. or over, but less than 4 in.....	No. 11 B.W.G.
Diameter 4 in. or over, but less than 5 in.....	No. 10 B.W.G.
Diameter 5 in.....	No. 9 B.W.G.

For higher maximum allowable working pressures than given above the thicknesses shall be increased one gage.

SPECIFICATIONS FOR BOILER PLATE STEEL

THESE SPECIFICATIONS¹ ARE SIMILAR TO THOSE OF THE AMERICAN SOCIETY FOR TESTING MATERIALS, SERIAL DESIGNATION A 30-14.

23 *Grades.* These specifications cover two grades of steel for boilers, namely: FLANGE and FIREBOX.

I MANUFACTURE

24 *Process.* The steel shall be made by the open-hearth process.

II CHEMICAL PROPERTIES AND TESTS

25 *Chemical Composition.* The steel shall conform to the following requirements as to chemical composition:

	FLANGE	FIREBOX
Carbon.....	.....	Plates $\frac{3}{4}$ in. thick and under . . 0.12—0.25 per cent Plates over $\frac{3}{4}$ in. thick. 0.12—0.30 per cent
Manganese.....	0.30—0.60 per cent	0.30—0.50 per cent
Phosphorus {		
Acid.	Not over 0.05 per cent	Not over 0.04 per cent
Basic.....	Not over 0.04 per cent	Not over 0.035 per cent
Sulphur.....	Not over 0.05 per cent	Not over 0.04 per cent
Copper.....	.....	Not over 0.05 per cent

26 *Ladle Analyses.* An analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given to the purchaser or his representative. This analysis shall conform to the requirements specified in Par. 25.

27 *Check Analyses.* Analyses may be made by the purchaser from a broken tension test specimen representing each plate as rolled, which shall conform to the requirements specified in Par. 25.

¹Approved and recommended in its modified form, October 9, 1914, by the Association of American Steel Manufacturers, the American Boiler Manufacturers' Association, the National Tubular Boiler Manufacturers' Association, the National Association of Thresher Manufacturers and the representatives present of leading Water Tube Boiler Manufacturers, with whom the Boiler Code Committee was in conference on September 16, 1914, and by whom further modifications were afterwards offered.

III PHYSICAL PROPERTIES AND TESTS

28 *Tension Tests.* *a* The material shall conform to the following requirements as to tensile properties:

	FLANGE	FIREBOX
Tensile strength, lb. per sq. in.	55,000—65,000	55,000—63,000
Yield point, min., lb. per sq. in.	0.5 tens. str.	0.5 tens. str.
Elongation in 8-in., min., per cent (See Par. 29)	<u>1,500,000</u> Tens. str.	<u>1,500,000</u> Tens. str.

b If desired steel of lower tensile strength than the above may be used in an entire boiler, or part thereof, the desired tensile limits to be specified, having a range of 10,000 lb. per sq. in. for flange or 8000 lb. per sq. in. for firebox, the steel to conform in all respects to the other corresponding requirements herein specified, and to be stamped with the minimum tensile strength of the stipulated range.

c The yield point shall be determined by the drop of the beam of the testing machine.

29 *Modifications in Elongation.* *a* For material over $\frac{3}{4}$ in. in thickness, a deduction of 0.5 from the percentages of elongation specified in Par. 28*a*, shall be made for each increase of $\frac{1}{8}$ in. in thickness above $\frac{3}{4}$ in., to a minimum of 20 per cent.

b For material $\frac{1}{4}$ in. or under in thickness, the elongation shall be measured on a gage length of 24 times the thickness of the specimen.

30 *Bend Tests.* *a Cold-bend Tests*—The test specimen shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in thickness, flat on itself; and for material over 1 in. in thickness, around a pin the diameter of which is equal to the thickness of the specimen.

b Quench-bend Tests—The test specimen, when heated to a light cherry red as seen in the dark (not less than 1200 deg. fahr.), and quenched at once in water the temperature of which is between 80 deg. and 90 deg. fahr., shall bend through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in thickness, flat on itself; and for material over 1 in. in thickness, around a pin the diameter of which is equal to the thickness of the specimen.

31 *Homogeneity Tests.* For firebox steel, a sample taken from a broken tension test specimen shall not show any single seam or cavity more than $\frac{1}{4}$ in. long, in either of the three fractures obtained in the test for homogeneity, which shall be made as follows:

The specimen shall be either nicked with a chisel or grooved on a machine, transversely, about $1/16$ in. deep, in three places about 2 in. apart. The first groove shall be made 2 in. from the square end; each succeeding groove shall be made on the opposite side from the preceding one. The specimen shall then be firmly held in a vise, with the first groove about $1/4$ in. above the jaws, and the projecting end broken off by light blows of a hammer, the bending being away from the groove. The specimen shall be broken at the other two grooves in the same manner. The object of this test is to open and render visible to the eye any seams due to failure to weld or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. One side of each fracture shall be examined and the length of the seams and cavities determined, a pocket lens being used if necessary.

32 *Test Specimens.* Tension and bend test specimens shall be taken from the finished rolled material. They shall be of the full

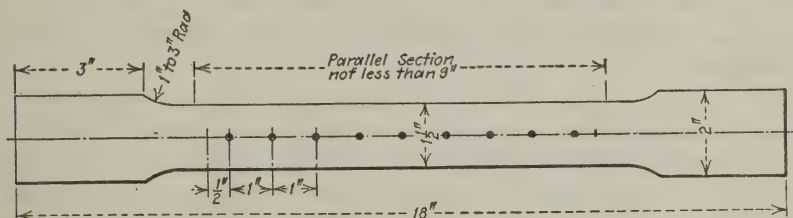


FIG. 1 STANDARD FORM OF TEST SPECIMEN REQUIRED FOR ALL TENSION TESTS OF PLATE MATERIAL

thickness of material as rolled, and shall be machined to the form and dimensions shown in Fig. 1; except that bend test specimens may be machined with both edges parallel.

33 *Number of Tests.* *a* One tension, one cold-bend, and one quench-bend test shall be made from each plate as rolled.

b If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

c If the percentage of elongation of any tension test specimen is less than that specified in Pars. 28 and 29, and any part of the fracture is outside the middle third of the gaged length, as indicated by the scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV PERMISSIBLE VARIATION IN GAGE

34 *Permissible Variation.* The thickness of each plate shall not vary under the gage specified more than 0.01 in. The overweight

limits are considered a matter of contract between the steel manufacturer and the boiler builder.

V FINISH

35 *Finish.* The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI MARKING

36 *Marking.* *a* Each shell plate shall be legibly stamped by the manufacturer with the melt or slab number, name of manufacturer, grade and the minimum tensile strength of the stipulated range as specified in Par. 28, in three places, two of which shall be located at diagonal corners about 12 in. from the edge and one about the center of the plate, or at a point selected and designated by the purchaser so that the stamp shall be plainly visible when the boiler is completed.

b Each head shall be legibly stamped by the manufacturer in two places, about 12 in. from the edge, with the melt or slab number, name of manufacturer, grade, and the minimum tensile strength of the stipulated range as specified in Par. 28, in such manner that the stamp is plainly visible when the boiler is completed.

c Each butt strap shall be legibly stamped by the manufacturer in two places on the center line about 12 in. from the ends with the melt or slab number, name of manufacturer, grade, and the minimum tensile strength of the stipulated range as specified in Par. 28.

d The melt or slab number shall be legibly stamped on each test specimen.

VII INSPECTION AND REJECTION

37 *Inspection.* The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

38 *Rejection.* *a* Unless otherwise specified, any rejection based on tests made in accordance with Par. 27 shall be reported within five working days from the receipt of samples.

b Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

39 *Rehearing.* Samples tested in accordance with Par. 27, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

SPECIFICATIONS FOR BOILER RIVET STEEL

THESE SPECIFICATIONS ARE SUBSTANTIALLY THE SAME AS THOSE OF THE AMERICAN SOCIETY FOR TESTING MATERIALS, SERIAL DESIGNATION A 31-14.

A REQUIREMENTS FOR ROLLED BARS

I MANUFACTURE

40 *Process.* The steel shall be made by the open-hearth process.

II CHEMICAL PROPERTIES AND TESTS

41 *Chemical Composition.* The steel shall conform to the following requirements as to chemical composition:

Manganese	0.30-0.50	per cent
Phosphorus	not over 0.04	per cent
Sulphur	not over 0.045	per cent

42 *Ladle Analyses.* An analysis to determine the percentages of carbon, manganese, phosphorus and sulphur shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given to the purchaser or his representative. This analysis shall conform to the requirements specified in Par. 41.

43 *Check Analyses.* Analyses may be made by the purchaser from finished bars, representing each melt, which shall conform to the requirements specified in Par. 41.

III PHYSICAL PROPERTIES AND TESTS

44 *Tension Tests.* *a* The bars shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in.....	45,000-55,000
Yield point, min., lb. per sq. in.....	0.5 tens. str.
Elongation in 8 in., min., per cent.....	1,500,000
but need not exceed 30 per cent.	Tens. str.

b The yield point shall be determined by the drop of the beam of the testing machine.

45 *Bend Tests.* *a Cold-bend Tests*—The test specimen shall bend cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

b Quench-bend Tests—The test specimen, when heated to a light cherry red as seen in the dark (not less than 1200 deg. fahr.), and quenched at once in water the temperature of which is between 80 deg. and 90 deg. fahr., shall bend through 180 deg. flat on itself without cracking on the outside of the bent portion.

46 *Test Specimens.* Tension and bend test specimens shall be of the full-size section of bars as rolled.

47 *Number of Tests.* *a* Two tension, two cold-bend, and two quench-bend tests shall be made from each melt, each of which shall conform to the requirements specified.

b If any test specimen develops flaws, it may be discarded and another specimen substituted.

c If the percentage of elongation of any tension test specimen is less than that specified in Par. 44 and any part of the fracture is outside the middle third of the gaged length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

48 *Permissible Variations in Gage.* The gage of each bar shall not vary more than 0.01 in. from that specified.

V WORKMANSHIP AND FINISH

49 *Workmanship.* The finished bars shall be circular within 0.01 in.

50 *Finish.* The finished bars shall be free from injurious defects and shall have a workmanlike finish.

VI MARKING

51 *Marking.* Rivet bars shall, when loaded for shipment, be properly separated and marked with the name or brand of the manufacturer and the melt number for identification. The melt number shall be legibly marked on each test specimen.

VII INSPECTION AND REJECTION

52 *Inspection.* The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bars ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bars are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

53 *Rejection.* *a* Unless otherwise specified, any rejection based on tests made in accordance with Par. 43 shall be reported within five working days from the receipt of samples.

b Bars which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

54 *Rehearing.* Samples tested in accordance with Par. 43, which represent rejected bars, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

B REQUIREMENTS FOR RIVETS

I PHYSICAL PROPERTIES AND TESTS

55 *Tension Tests.* The rivets, when tested, shall conform to the requirements as to tensile properties specified in Par. 44, except that the elongation shall be measured on a gaged length not less than four times the diameter of the rivet.

56 *Bend Tests.* The rivet shank shall bend cold through 180 deg. flat on itself, as shown in Fig. 2, without cracking on the outside of the bent portion.

57 *Flattening Tests.* The rivet head shall flatten, while hot, to a diameter $2\frac{1}{2}$ times the diameter of the shank, as shown in Fig. 3, without cracking at the edges.

58 *Number of Tests.* a When specified, one tension test shall be made from each size in each lot of rivets offered for inspection.

b Three bend and three flattening tests shall be made from each size in each lot of rivets offered for inspection, each of which shall conform to the requirements specified.

II WORKMANSHIP AND FINISH

59 *Workmanship.* The rivets shall be true to form, concentric, and shall be made in a workmanlike manner.

60 *Finish.* The finished rivets shall be free from injurious defects.

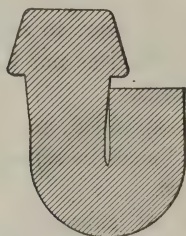


FIG. 2 THE BEND
TEST FOR RIVETS

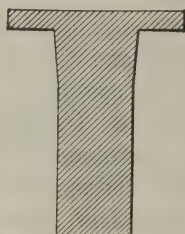


FIG. 3 THE FLAT-
TENING TEST FOR
RIVETS

III INSPECTION AND REJECTION

61 *Inspection.* The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the rivets ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the rivets are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

62 *Rejection.* Rivets which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

SPECIFICATIONS FOR STAYBOLT STEEL

REQUIREMENTS FOR ROLLED BARS

63 Steel for staybolts shall conform to the requirements for Boiler Rivet Steel specified in Pars. 40 to 62, except that the tensile properties shall be as follows:

Tensile strength, lb. per sq. in.	50,000–60,000
Yield point, min., lb. per sq. in.	0.5 tens. str. 1,500,000
Elongation in 8 in., min., per cent.	_____
	Tens. str.

Also with the exception that the permissible variations in gage shall be as follows:

Permissible Variations in Gage. The bars shall be truly round within 0.01 in. and shall not vary more than 0.005 in. above, or more than 0.01 in. below the specified size.

SPECIFICATIONS FOR STEEL BARS

THESE SPECIFICATIONS ARE ABSTRACTED FROM THOSE FOR STEEL FOR BRIDGES OF THE AMERICAN SOCIETY FOR TESTING MATERIALS, SERIAL DESIGNATION A 7-14.

I MANUFACTURE

64 *Process.* The steel shall be made by the open-hearth process.

II CHEMICAL PROPERTIES AND TESTS

65 *Chemical Composition.* The steel shall conform to the following requirements as to chemical composition:

Phosphorus	{ Acid	not over 0.06 per cent
	{ Basic	not over 0.04 per cent
Sulphur		not over 0.05 per cent

66 *Ladle Analysis.* An analysis to determine the percentages of carbon, manganese, phosphorus and sulphur shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given to the purchaser or his representative. This analysis shall conform to the requirements specified in Par. 65.

III PHYSICAL PROPERTIES AND TESTS

67 *Tension Tests.* *a* The material shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in.....	55,000-65,000
Yield point, min., per sq. in.....	0.5 tens. str. 1,500,000
Elongation in 8 in., min., per cent*.....	————— Tens. str.
Elongation in 2 in., min., per cent.....	22

*See Par. 68.

b The yield point shall be determined by the drop of the beam of the testing machine.

68 *Modifications in Elongation.* *a* For bars over $\frac{3}{4}$ in. in thickness or diameter a deduction of 1 from the percentage of elongation in 8 in. specified in Par. 67, shall be made for each increase of $\frac{1}{8}$ in. in thickness or diameter above $\frac{3}{4}$ in., to a minimum of 18 per cent.

b For bars under $\frac{5}{16}$ in. in thickness or diameter a deduction of 2.5 from the percentage of elongation in 8 in. specified in Par. 67, shall be made for each decrease of $\frac{1}{16}$ in. in thickness or diameter below $\frac{5}{16}$ in.

69 *Bend Tests.* *a* The test specimen shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material $\frac{3}{4}$ in. or under in thickness or diameter flat on itself; for material over $\frac{3}{4}$ in. to and including $1\frac{1}{4}$ in. in thickness or diameter around a pin the diameter of which is equal to the thickness or diameter of the specimen; and for material over $1\frac{1}{4}$ in. in thickness or diameter around a pin the diameter of which is equal to twice the thickness or diameter of the specimen.

b The test specimen for bars over $1\frac{1}{2}$ in. in thickness or diameter when prepared as specified in Par. 70, shall bend cold through 180 deg. around a 1-in. pin without cracking on the outside of the bent portion.

70 *Test Specimens.* *a* Tension and bend test specimens except as specified in *b*, shall be of the full thickness of material as rolled. They may be machined to the form and dimensions shown in Fig. 1, or may have both edges parallel.

b Tension test specimens for bars over $1\frac{1}{2}$ in. in thickness or diameter may be of the form and dimensions shown in Fig. 4. Bend

test specimens may be 1 by $\frac{1}{2}$ in. in section. The axis of the specimen shall be located at any point midway between the center and surface and shall be parallel to the axis of the bar.

71 *Number of Tests.* *a* One tension and one bend test shall be made from each melt; except that if material from one melt differs $\frac{3}{8}$ in. or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

b If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

c If the percentage of elongation of any tension test specimen is less than that specified in Par. 67, and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length of a 2-in. specimen or is outside the middle third of the gage length of an 8-in. specimen, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV PERMISSIBLE VARIATIONS IN GAGE

72 *Permissible Variation.* The thickness or cross-section of each piece of steel shall not vary under that specified more than 2.5 per cent. (NOTE: Overweight variation is a matter of contract between the steel manufacturer and boiler builder.)

V FINISH

73 *Finish.* The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI MARKING

74 *Marking.* Bars shall, when loaded for shipment, be properly separated and marked with the name or brand of the manufacturer and melt number for identification. The melt number shall be legibly marked on each test specimen.

VII INSPECTION AND REJECTION

75 *Inspection.* The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works

which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

76 *Rejection.* Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

SPECIFICATIONS FOR STEEL CASTINGS

THESE SPECIFICATIONS ARE ABSTRACTED FROM THOSE FOR STEEL CASTINGS OF THE AMERICAN SOCIETY FOR TESTING MATERIALS, SERIAL DESIGNATION A 27-14.

77 *Classes.* These specifications cover two classes of castings, namely:

Class A, ordinary castings for which no physical requirements are specified.

Class B, castings for which physical requirements are specified.

These are of three grades: hard, medium, and soft.

78 *Patterns.* *a* Patterns shall be made so that sufficient finish is allowed to provide for all variations in shrinkage.

b Patterns shall be painted three colors to represent metal, cores, and finished surfaces. It is recommended that core prints shall be painted black and finished surfaces red.

79 *Basis of Purchase.* The purchaser shall indicate his intention to substitute the test to destruction specified in Par. 87, for the tension and bend tests, and shall designate the patterns from which castings for this test shall be made.

I MANUFACTURE

80 *Process.* The steel may be made by the open-hearth, crucible, or any other process approved by the purchaser.

81 *Heat Treatment.* *a* Class A castings need not be annealed unless so specified.

b Class B castings shall be allowed to become cold. They shall then be uniformly reheated to the proper temperature to refine the

grain (a group thus reheated being known as an "annealing charge"), and allowed to cool uniformly and slowly. If, in the opinion of the purchaser or his representative, a casting is not properly annealed, he may at his option require the casting to be re-annealed.

II CHEMICAL PROPERTIES AND TESTS

82 *Chemical Composition.* The castings shall conform to the following requirements as to chemical composition:

	Class A	Class B
Carbon	not over 0.30 per cent	.....
Phosphorus	not over 0.06 per cent	not over 0.05 per cent
Sulphur .....	.....	not over 0.05 per cent

83 *Ladle Analyses.* An analysis to determine the percentages of carbon, manganese, phosphorus and sulphur shall be made by the manufacturer from a test ingot taken during the pouring of each melt, a copy of which shall be given to the purchaser or his representative. This analysis shall conform to the requirements specified in Par. 82. Drillings for analysis shall be taken not less than $\frac{1}{4}$ in. beneath the surface of the test ingot.

84 *Check Analyses.* *a* Analyses of Class A castings may be made by the purchaser, in which case an excess of 20 per cent above the requirement as to phosphorus specified in Par. 82, shall be allowed. Drillings for analysis shall be taken not less than $\frac{1}{4}$ in beneath the surface.

b Analyses of Class B castings may be made by the purchaser from a broken tension or bend test specimen, in which case an excess of 20 per cent above the requirements as to phosphorus and sulphur specified in Par. 82, shall be allowed. Drillings for analysis shall be taken not less than $\frac{1}{4}$ in. beneath the surface.

III PHYSICAL PROPERTIES AND TESTS

(For Class B Castings only.)

85 *Tension Tests.* *a* The castings shall conform to the following minimum requirements as to tensile properties:

	Hard	Medium	Soft
Tensile strength, lb. per sq. in.....	80,000	70,000	60,000
Yield point, lb. per sq. in.....	36,000	31,500	27,000
Elongation in 2 in., per cent.....	15	18	22
Reduction of area, per cent.....	20	25	30

b The yield point shall be determined by the drop of the beam of the testing machine.

86 *Bend Tests.* *a* The test specimen for soft castings shall bend cold through 120 deg., and for medium castings through 90 deg., around a 1-in. pin, without cracking on the outside of the bent portion.

b Hard castings shall not be subject to bend test requirements.

87 *Alternative Tests to Destruction.* In the case of small or unimportant castings, a test to destruction on three castings from a lot may be substituted for the tension and bend tests. This test shall show the material to be ductile, free from injurious defects, and suitable for the purpose intended. A lot shall consist of all castings from one melt, in the same annealing charge.

88 *Test Specimens.* *a* Sufficient test bars, from which the test specimens required in Par. 89, may be selected, shall be attached to castings weighing 500 lb. or over, when the design of the castings will permit. If the castings weigh less than 500 lb., or are of such a design that test bars cannot be attached, two test bars shall be cast to represent each melt; or the quality of the castings shall be determined by tests to destruction as specified in Par. 87. All test bars shall be annealed with the castings they represent.

b The manufacturer and purchaser shall agree whether test bars can be attached to castings, on the location of the bars on the castings, on the castings to which bars are to be attached, and on the method of casting unattached bars.

c Tension test specimens shall be of the form and dimensions shown in Fig. 4. Bend test specimens shall be machined to 1 by ½ in. in section with corners rounded to a radius not over 1/16 in.

89 *Number of Tests.* *a* One tension and one bend test shall be made from each annealing charge. If more than one melt is represented in an annealing charge, one tension and one bend test shall be made from each melt.

b If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser or his representative shall agree upon the selection of another specimen in its stead.

c If the percentage of elongation of any tension test specimen is less than that specified in Par. 85, and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gaged length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV WORKMANSHIP AND FINISH

90 *Workmanship.* The castings shall substantially conform to the sizes and shapes of the patterns, and shall be made in a workmanlike manner.

91 *Finish.* a The castings shall be free from injurious defects.

b Minor defects which do not impair the strength of the castings may, with the approval of the purchaser or his representative, be

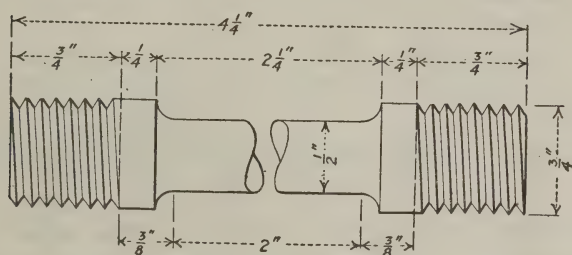


FIG. 4 STANDARD FORM OF TEST SPECIMEN REQUIRED FOR ALL TENSION TESTS OF STEEL CASTING MATERIAL

welded by an approved process. The defects shall first be cleaned out to solid metal; and after welding, the castings shall be annealed, if specified by the purchaser or his representative.

c The castings offered for inspection shall not be painted or covered with any substance that will hide defects, nor rusted to such an extent as to hide defects.

V INSPECTION AND REJECTION

92 *Inspection.* The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the castings are being furnished in accordance with

these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

93 *Rejection.* *a* Unless otherwise specified, any rejection based on tests made in accordance with Par. 84, shall be reported within five working days from the receipt of samples.

b Castings which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

94 *Rehearing.* Samples tested in accordance with Par. 84, which represent rejected castings, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

SPECIFICATIONS FOR GRAY IRON CASTINGS

THESE SPECIFICATIONS ARE IDENTICAL WITH THOSE OF THE AMERICAN SOCIETY FOR TESTING MATERIALS, SERIAL DESIGNATION A 48-05.

95 *Process of Manufacture.* Unless furnace iron is specified, all gray castings are understood to be made by the cupola process.

96 *Chemical Properties.* The sulphur contents to be as follows:

Light castings	not over 0.08 per cent
Medium castings	not over 0.10 per cent
Heavy Castings	not over 0.12 per cent

97 *Classification.* In dividing castings into light, medium and heavy classes, the following standards have been adopted:

98 Castings having any section less than $\frac{1}{2}$ in. thick shall be known as *light castings*.

99 Castings in which no section is less than 2 in. thick shall be known as *heavy castings*.

100 *Medium castings* are those not included in the above classification.

PHYSICAL PROPERTIES AND TESTS

101 *Transverse Test.* The minimum breaking strength of the "Arbitration Bar" under transverse load shall be not under:

Light castings	2500 lbs.
Medium castings	2900 lbs.
Heavy castings	3300 lbs.

In no case shall the deflection be under 0.10 in.

102 *Tensile Test.* Where specified, this shall not run less than:

Light castings	18,000 lb. per sq. in.
Medium castings	21,000 lb. per sq. in.
Heavy castings	24,000 lb. per sq. in.

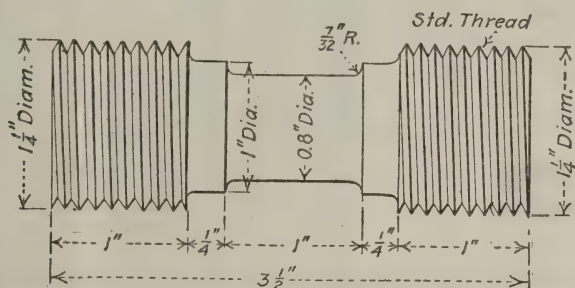


FIG. 5 STANDARD FORM OF TEST SPECIMEN REQUIRED FOR TENSION TESTS OF GRAY-IRON CASTING MATERIAL

103 *Arbitration Bar.* The quality of the iron going into castings under specification shall be determined by means of the "Arbitration Bar." This is a bar $1\frac{1}{4}$ in. in diameter and 15 in. long. It shall be prepared as stated further on and tested transversely. The tensile test is not recommended, but in case it is called for, the bar as shown in Fig. 5, and turned up from any of the broken pieces of the transverse test shall be used. The expense of the tensile test shall fall on the purchaser.

104 *Number of Test Bars.* Two sets of two bars shall be cast from each heat, one set from the first and the other set from the last iron going into the castings. Where the heat exceeds twenty tons, an additional set of two bars shall be cast for each twenty tons or fraction thereof above this amount. In case of a change of mixture during the heat, one set of two bars shall also be cast for every mixture other

than the regular one. Each set of two bars is to go into a single mold. The bars shall not be rumbled or otherwise treated, being simply brushed off before testing.

105 *Method of Testing.* The transverse test shall be made on all the bars cast, with supports 12 in. apart, load applied at the middle,

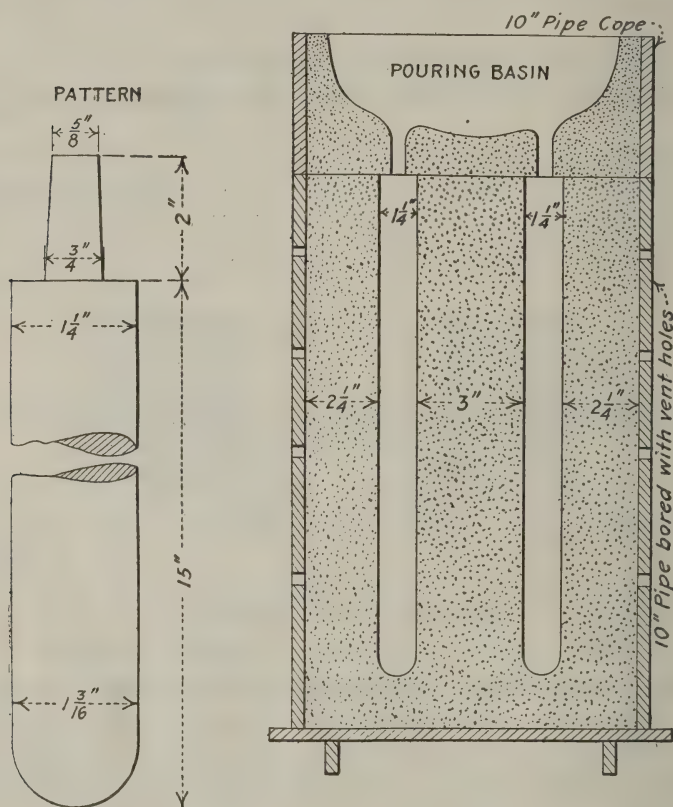


FIG. 6 DETAILS OF PATTERN AND MOLD REQUIRED FOR ARBITRATION BARS IN TESTING GRAY-IRON CASTING MATERIAL

and the deflection at rupture noted. One bar of every two of each set made must fulfill the requirements to permit acceptance of the castings represented.

106 *Mold for Test Bar.* The mold for the bars is shown in Fig. 6. The bottom of the bar is $1/16$ in. smaller in diameter than the top, to allow for draft and for the strain of pouring. The pattern shall not be rapped before withdrawing. The flask is to be rammed up

with green molding sand, a little damper than usual, well mixed and put through a No. 8 sieve, with a mixture of one to twelve bituminous facing. The mold shall be rammed evenly and fairly hard, thoroughly dried and not cast until it is cold. The test bar shall not be removed from the mold until cold enough to be handled.

107 *Speed of Testing.* The rate of application of the load shall be from 20 to 40 seconds for a deflection of 0.10 in.

108 *Samples for Analysis.* Borings from the broken pieces of the "Arbitration Bar" shall be used for the sulphur determinations. One determination for each mold made shall be required. In case of dispute, the standards of the American Foundrymen's Association shall be used for comparison.

109 *Finish.* Castings shall be true to pattern, free from cracks, flaws and excessive shrinkage. In other respects they shall conform to whatever points may be specially agreed upon.

110 *Inspection.* The inspector shall have reasonable facilities afforded him by the manufacturer to satisfy him that the finished material is furnished in accordance with these specifications. All tests and inspections shall, as far as possible, be made at the place of manufacture prior to shipment.

SPECIFICATIONS FOR MALLEABLE CASTINGS

THESE SPECIFICATIONS ARE IDENTICAL WITH THOSE OF THE AMERICAN SOCIETY FOR TESTING MATERIALS, SERIAL DESIGNATION A 47-04.

111 *Process of Manufacture.* Malleable iron castings may be made by the open-hearth, air furnace, or cupola process. Cupola iron, however, is not recommended for heavy nor for important castings.

112 *Chemical Properties.* Castings for which physical requirements are specified shall not contain over 0.06 sulphur nor over 0.225 phosphorus.

PHYSICAL PROPERTIES AND TESTS

113 *Standard Test Bar.* This bar shall be 1 in. sq. and 14 in. long, without chills and with ends left perfectly free in the mold. Three shall be cast in one mold, heavy risers insuring sound bars. Where the full heat goes into castings which are subject to specifica-

tion, one mold shall be poured two minutes after tapping into the first ladle, and another mold from the last iron of the heat. Molds shall be suitably stamped to insure identification of the bars, the bars being annealed with the castings. Where only a partial heat is required for the work in hand, one mold should be cast from the first ladle used and another after the required iron has been tapped.

a Of the three test bars from the two molds required for each heat, one shall be tested for tensile strength and elongation, the other for transverse strength and deflection. The other remaining bar is reserved for either the transverse or tensile test, in case of the failure of the two other bars to come up to requirements. The halves of the bars broken transversely may also be used for the tensile test.

b Failure to reach the required limit for the tensile strength with elongation, as also the transverse strength with deflection, on the part of at least one test, shall reject the castings from that heat.

114 *Tensile Test.* The tensile strength of a standard test bar for castings under specification shall not be less than 40,000 lb. per sq. in. The elongation measured in 2 in. shall not be less than $2\frac{1}{2}$ per cent.

115 *Transverse Test.* The transverse strength of a standard test bar, on supports 12 in. apart, pressure being applied at the center, shall not be less than 3000 lb., deflection being at least $\frac{1}{2}$ in.

116 *Test Lugs.* Castings of special design or of special importance may be provided with suitable test lugs at the option of the inspector. At least one of these lugs shall be left on the casting for his inspection upon his request therefor.

117 *Annealing.* Malleable castings shall neither be "over" nor "under" annealed. They must have received their full heat in the oven at least sixty hours after reaching that temperature.

118 The "saggers" shall not be dumped until the contents shall at least be "black hot."

119 *Finish.* Castings shall be true to pattern, free from blemishes, scale or shrinkage cracks. A variation of $\frac{1}{16}$ in. per foot shall be permissible. Founders shall not be held responsible for defects due to irregular cross sections and unevenly distributed metal.

120 *Inspection.* The inspector representing the purchaser shall have all reasonable facilities given him by the founder to satisfy him that the finished material is furnished in accordance with these specifications. All tests and inspections shall be made prior to shipment.

SPECIFICATIONS FOR BOILER RIVET IRON

THESE REQUIREMENTS ARE AN ADAPTATION, WITH SLIGHT MODIFICATIONS IN THE PHYSICAL PROPERTIES AND TESTS, OF THE SPECIFICATIONS FOR ENGINE BOLT IRON OF THE AMERICAN SOCIETY FOR TESTING MATERIALS.

A REQUIREMENTS FOR ROLLED BARS

I MANUFACTURE

121 *Process.* The iron shall be made wholly from puddled iron or knobbled charcoal iron, and shall be free from any admixture of iron scrap or steel.

122 *Iron Scrap.* This term applies only to foreign or bought scrap and does not include local mill products free from foreign or bought scrap.

II PHYSICAL PROPERTIES AND TESTS

123 *Tension Tests.* *a* The iron shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in.....	48,000–52,000
Yield point, min., lb. per sq. in.....	0.6 tens. str.
Elongation in 8 in., min., per cent.....	28
Reduction of area, min., per cent.....	45

b The yield point shall be determined by the drop of the beam of the testing machine. The speed of the cross-head of the machine shall not exceed $1\frac{1}{2}$ in. per minute.

124 *Bend Tests.* *a Cold-bend Tests*—The test specimen shall bend cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

b Hot-bend Tests—The test specimen, when heated to a bright cherry red, shall bend through 180 deg. flat on itself, without fracture on the outside of the bent portion.

c Nick-bend Tests—The test specimen, when nicked 25 per cent around with a tool having a 60-deg. cutting edge, to a depth of not less than 8 nor more than 16 per cent of the diameter of the specimen, and broken, shall show a wholly fibrous fracture.

d Bend tests may be made by pressure or by blows.

125 *Etch Tests.*¹ The cross-section of the test specimen shall be ground or polished, and etched for a sufficient period to develop the structure. This test shall show the material to be free from steel.

126 *Test Specimens.* All test specimens shall be of the full section of material as rolled.

127 *Number of Tests.* a Bars of one size shall be sorted into lots of 100 each. Two bars shall be selected at random from each lot or fraction thereof, and tested as specified in Pars. 123 and 124; but only one of these bars shall be tested as specified in Par. 125.

b If any test specimen from either of the bars originally selected to represent a lot of material, contains surface defects not visible before testing but visible after testing, or if a tension test specimen breaks outside the middle third of the gage length, one retest from a different bar will be allowed.

III PERMISSIBLE VARIATIONS IN GAGE

128 *Permissible Variations.* The gage of each bar shall not vary more than 0.01 in. from that specified.

IV FINISH

129 *Finish.* The bars shall be smoothly rolled and free from slivers, depressions, seams, crop ends and evidences of being burnt.

V MARKING

130 *Marking.* The bars shall be stamped or marked as designated by the purchaser.

VI INSPECTION AND REJECTION

131 *Inspection.* a The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with

¹A solution of two parts water, one part concentrated hydrochloric acid, and one part concentrated sulphuric acid is recommended for the etch test.

these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

b The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

132 *Rejection.* If either of the test bars selected to represent a lot does not conform to the requirements specified in Pars. 123, 124 and 125, the lot will be rejected.

B REQUIREMENTS FOR RIVETS

• I PHYSICAL PROPERTIES AND TESTS

133 *Number of Tests.* When specified, three rivets of each diameter shall be taken at random from each lot offered for inspection, and if they fail to stand the following tests the lot will be rejected.

134 *Bend Tests.* *a* The rivet shank shall bend cold through 180 deg. flat on itself, as shown in Fig. 2, without cracking on the outside of the bent portion.

b The heads must stand bending back, showing that they are firmly joined.

c When nicked and broken gradually the fracture must show a clean, long and fibrous iron.

II WORKMANSHIP AND FINISH

135 *Workmanship.* The rivets shall be true to form, concentric, and shall be made in a workmanlike manner.

136 *Finish.* The finished rivets shall be free from injurious defects.

III INSPECTION AND REJECTION

137 *Inspection.* The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the rivets ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the rivets are being furnished in accordance with these specifications. All tests and inspection shall be made at the

place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

138 *Rejection.* Rivets which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

SPECIFICATIONS FOR STAYBOLT IRON

THESE SPECIFICATIONS ARE IDENTICAL WITH THOSE OF THE AMERICAN SOCIETY FOR TESTING MATERIALS, SERIAL DESIGNATION A 39-14.

I MANUFACTURE

139 *Process.* The iron shall be rolled from a bloom or boxpile, made wholly from puddled iron or knobbed charcoal iron. The puddle mixture and the component parts of the bloom or boxpile shall be free from any admixture of iron scrap or steel:

140 *Definition of Terms.* *a Bloom*—A bloom is a solid mass of iron that has been hammered into a convenient size for rolling.

b Boxpile—A boxpile is a pile, the sides, top and bottom of which are formed by four flat bars and the interior of which consists of a number of small bars the full length of the pile.

c Iron Scrap—This term applies only to foreign or purchased scrap and does not include local mill products free from foreign or purchased scrap.

II PHYSICAL PROPERTIES AND TESTS

141 *Tension Tests.* *a* The iron shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in.....	49,000–53,000
Yield point, min., lb. per sq. in.....	0.6 tens. str.
Elongation in 8 in., min., per cent.....	30
Reduction of area, min., per cent.....	48

b The yield point shall be determined by the drop of the beam of the testing machine. The speed of the cross-head of the machine shall not exceed 1½ in. per minute.

142 *Bend Tests.* *a Cold-bend Tests*—The test specimen shall bend cold through 180 deg. flat on itself in both directions without fracture on the outside of the bent portion.

b Quench-bend Tests—The test specimen, when heated to a yellow heat and quenched at once in water the temperature of which is between 80 deg. and 90 deg. fahr., shall bend through 180 deg. flat on itself without fracture on the outside of the bent portion.

c Nick-bend Tests—The test specimen, when nicked 25 per cent around with a tool having a 60-deg. cutting edge, to a depth of not less than 8 nor more than 16 per cent of the diameter of the specimen, and broken, shall show a clean fiber entirely free from crystallization.

d Bend tests may be made by pressure or by blows.

143 *Etch Tests.*¹ The cross-section of the test specimen shall be ground or polished, and etched for a sufficient period to develop the structure. This test shall show the material to have been rolled from a bloom or a boxpile, and to be free from steel.

144 *Test Specimens.* All test specimens shall be of the full section of material as rolled.

145 *Number of Tests.* *a* Bars of one size shall be sorted into lots of 100 each. Two bars shall be selected at random from each lot or fraction thereof, and tested as specified in Pars. 141 and 142; but only one of these bars shall be tested as specified in Par. 143.

b If any test specimen from either of the bars originally selected to represent a lot of material, contains surface defects not visible before testing but visible after testing, or if a tension test specimen breaks outside the middle third of the gage length, one retest from a different bar will be allowed.

c When retests as specified in *b* are not permitted, a reduction of 2 per cent in elongation and 3 per cent in reduction of area from that specified in Par. 141, shall be allowed.

III PERMISSIBLE VARIATIONS IN GAGE

146 *Permissible Variations.* The bars shall be truly round within 0.01 in., and shall not vary more than 0.005 in. above or more than 0.01 in. below the specified size.

¹A solution of two parts water, one part concentrated hydrochloric acid, and one part concentrated sulphuric acid is recommended for the etch test.

IV FINISH

147 *Finish.* The bars shall be smoothly rolled and free from slivers, depressions, seams, crop ends and evidences of being burnt.

V MARKING

148 *Marking.* The bars shall be stamped or marked as designated by the purchaser.

VI INSPECTION AND REJECTION

149 *Inspection.* *a* The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

b The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

150 *Rejection.* *a* If either of the test bars selected to represent a lot does not conform to the requirements specified in Pars. 141, 142 and 143, the lot will be rejected.

b Bars which will not take a clean, sharp thread with dies in fair condition, or which develop defects in forging or machining, will be rejected, and the manufacturer shall be notified.

SPECIFICATIONS FOR REFINED WROUGHT-IRON BARS

THESE SPECIFICATIONS ARE SIMILAR TO THOSE OF THE AMERICAN
SOCIETY FOR TESTING MATERIALS, SERIAL DESIGNATION A 41-13.

I MANUFACTURE

151 *Process.* Refined wrought-iron bars shall be made wholly from puddled iron, and may consist either of new muck-bar iron or a mixture of muck-bar iron and scrap, but shall be free from any admixture of steel.

II PHYSICAL PROPERTIES AND TESTS

152 *Tension Tests.* *a* The iron shall conform to the following minimum requirements as to tensile properties.

Tensile strength, lb. per sq. in.....	48,000
(See Pars. 153 and 154.)	
Yield point, lb. per sq. in.....	25,000
Elongation in 8 in., per cent.....	22
(See Par. 155.)	

b The yield point shall be determined by the drop of the beam of the testing machine. The speed of the cross-head of the machine shall not exceed $1\frac{1}{2}$ in. per minute.

153 *Permissible Variations.* Twenty per cent of the test specimens representing one size may show tensile strengths 1000 lb. per sq. in. under, or 5000 lb. per sq. in. over that specified in Par. 152; but no specimen shall show a tensile strength under 45,000 lb. per sq. in.

154 *Modifications in Tensile Strength.* For flat bars which have to be reduced in width, a deduction of 1000 lb. per sq. in. from the tensile strength specified in Pars. 152 and 153, shall be made.

155 *Permissible Variations in Elongation.* Twenty per cent of the test specimens representing one size may show the following percentages of elongation in 8 in.:

ROUND BARS

$\frac{1}{2}$ in. or over, tested as rolled.....	20 per cent
Under $\frac{1}{2}$ in., tested as rolled.....	16 per cent
Reduced by machining.....	18 per cent

FLAT BARS

$\frac{3}{8}$ in. or over, tested as rolled.....	18 per cent
Under $\frac{3}{8}$ in., tested as rolled.....	16 per cent
Reduced by machining.....	16 per cent

156 *Bend Tests. a Cold-bend Tests*—Cold bend tests will be made only on bars having a nominal area of 4 sq. in. or under, in which case the test specimen shall bend cold through 180 deg. without fracture on the outside of the bent portion, around a pin the diameter of which is equal to twice the diameter or thickness of the specimen.

b Hot-bend Tests—The test specimen, when heated to a temperature between 1700 deg. and 1800 deg. fahr., shall bend through 180 deg. without fracture on the outside of the bent portion, as follows: for round bars under 2 sq. in. in section, flat on itself; for round bars 2 sq. in. or over in section and for all flat bars, around a pin the diameter of which is equal to the diameter or thickness of the specimen.

c Nick-bend Tests—The test specimen, when nicked 25 per cent around for round bars, and along one side for flat bars, with a tool having a 60-deg. cutting edge, to a depth of not less than 8 nor more than 16 per cent of the diameter or thickness of the specimen, and broken, shall not show more than 10 per cent of the fracture surface to be crystalline.

d Bend tests may be made by pressure or by blows.

157 *Etch Tests.*¹ The cross-section of the test specimen shall be ground or polished, and etched for a sufficient period to develop the structure. This test shall show the material to be free from steel.

158 *Test Specimens. a Tension and bend test specimens* shall be of the full section of material as rolled, if possible; otherwise the specimens shall be machined from the material as rolled. The axis of the specimen shall be located at any point one-half the distance from the center to the surface of round bars, or from the center to the edge of flat bars, and shall be parallel to the axis of the bar.

b Etch test specimens shall be of the full section of material as rolled.

159 *Number of Tests. a All bars of one size* shall be piled separately. One bar from each 100 or fraction thereof will be selected at random and tested as specified.

b If any test specimen from the bar originally selected to represent a lot of material contains surface defects not visible before test-

¹A solution of two parts water, one part concentrated hydrochloric acid, and one part concentrated sulphuric acid is recommended for the etch test.

ing but visible after testing, or if a tension test specimen breaks outside the middle third of the gage length, one retest from a different bar will be allowed.

III PERMISSIBLE VARIATIONS IN GAGE

160 *Permissible Variations.* *a* Round bars shall conform to the standard limit gages adopted by the Master Car Builders' Association given in Table 2.

TABLE 2 PERMISSIBLE VARIATIONS IN GAGE FOR ROUND WROUGHT-IRON BARS

Nominal Diameter, Inches	Maximum Diameter, Inches	Minimum Diameter, Inches	Total Variation, Inches
$\frac{1}{4}$	0.2550	0.2450	0.010
$\frac{3}{8}$	0.3180	0.3070	0.011
$\frac{1}{2}$	0.3810	0.3690	0.012
$\frac{5}{8}$	0.4440	0.4310	0.013
$\frac{3}{4}$	0.5070	0.4930	0.014
$\frac{7}{8}$	0.5700	0.5550	0.015
$\frac{1}{2}$	0.6330	0.6170	0.016
$\frac{3}{4}$	0.7585	0.7415	0.017
$\frac{1}{2}$	0.8840	0.8660	0.018
1.....	1.0095	0.9905	0.019
$1\frac{1}{8}$	1.1350	1.1150	0.020
$1\frac{1}{4}$	1.2605	1.2395	0.021

b The widths or thicknesses of flat bars shall not vary more than 2 per cent from that specified.

IV FINISH

161 *Finish.* The bars shall be smoothly rolled and free from slivers, depressions, seams, crop ends and evidences of being burnt.

V INSPECTION AND REJECTION

162 *Inspection.* *a* The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

b The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

163 *Rejection.* All bars of one size will be rejected if the test specimens representing that size do not conform to the requirements specified.

SPECIFICATIONS FOR LAPWELDED AND SEAMLESS BOILER TUBES

Approved by the Boiler Tube Manufacturers of America
September 25, 1914

I MANUFACTURE

164 *Process.* *a* Lapwelded tubes shall be made of open-hearth steel or knobbled hammered charcoal iron.

b Seamless tubes shall be made of open-hearth steel.

II CHEMICAL PROPERTIES AND TESTS

165 *Chemical Composition.* *a* The steel shall conform to the following requirements as to chemical composition:

Carbon	0.08-0.18	per cent
Manganese	0.30-0.50	per cent
Phosphorus	not over 0.04	per cent
Sulphur	not over 0.045	per cent

b Chemical analyses will not be required for charcoal iron tubes.

166 *Check Analyses.* *a* Analyses of two tubes in each lot of 250 (or on total order if less than 250) may be made by the purchaser which shall conform to the requirements specified in Par. 165. Drillings for analyses shall be taken from several points around each tube.

b If the analysis of only one tube does not conform to the requirements specified, analyses of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

III PHYSICAL PROPERTIES AND TESTS

167 *Flange Test.* *a* A test specimen not less than 4 in. in length shall have a flange turned over at right angles to the body of the tube

ETCH TESTS FOR CHARCOAL IRON

173 *Etch Tests.*¹ A cross section of tube may be turned or ground to a perfectly true surface polished free from dirt or cracks, and etched until the soft parts are sufficiently dissolved for the iron tube to show a decided ridged surface with the weld very distinct, while a steel tube would show a homogeneous surface.

IV WORKMANSHIP AND FINISH

174 *Workmanship.* The finished tubes shall be circular within 0.02 in. and the mean outside diameter shall not vary more than 0.015 in. from the size ordered. All tubes shall be carefully gaged with a B.W.G. gage and shall not be less than the gage specified, except the tubes on which the standard slot gage, specified, will go on tightly at the thinnest point, will be accepted. The length shall not be less, but may be 0.125 in. more than that ordered.

175 *Finish.* The finished tubes shall be free from injurious defects and shall have a workmanlike finish and shall be practically free from kinks, bends and buckles.

V MARKING

176 *Marking.* The name or brand of the manufacturer, the material from which it is made, whether steel or charcoal iron, and "Tested at 1000 lb." for tubes under 5 in. in diameter, or "Tested at 800 lb." for tubes 5 in. in diameter or over, shall be legibly stenciled on each tube.

VI INSPECTION AND REJECTION

177 *Inspection.* All tests and inspection shall be made at the place of manufacture. The manufacturer of boiler tubes shall furnish the purchaser of each lot of tubes a statement of the kind of material of which the tubes are made, and that the tubes have been tested and have met all the requirements of these rules. This statement shall be furnished to the manufacturer using the tubes.

178 *Rejection.* Tubes when inserted in the boiler shall stand expanding and beading without showing cracks or flaws, or opening at the weld. Tubes which fail in this manner will be rejected and the manufacturer shall be notified.

¹A solution of two parts of water, one part concentrated hydrochloric acid, and one part concentrated sulphuric acid is recommended for the etch test.

CONSTRUCTION AND MAXIMUM ALLOWABLE WORKING PRESSURES FOR POWER BOILERS

179 *Maximum Allowable Working Pressure.* The maximum allowable working pressure is that at which a boiler may be operated as determined by employing the factors of safety, stresses, and dimensions designated in these Rules.

No boiler shall be operated at a higher pressure than the maximum allowable working pressure except when the safety valve or valves are blowing, at which time the maximum allowable working pressure shall not be exceeded by more than six per cent.

Wherever the term maximum allowable working pressure is used herein, it refers to gage pressure, or the pressure above the atmosphere, in pounds per square inch.

180 The maximum allowable working pressure on the shell of a boiler or drum shall be determined by the strength of the weakest course, computed from the thickness of the plate, the tensile strength stamped thereon, as provided for in Par. 36, the efficiency of the longitudinal joint, or of the ligament between the tube holes in shell or drum, (whichever is the least), the inside diameter of the course, and the factor of the safety.

$$\frac{TS \times t \times E}{R \times FS} = \text{maximum allowable working pressure, lb. per sq. in.}$$

where

TS = ultimate tensile strength stamped on shell plates, as provided for in Par. 36, lb. per sq. in.

t = minimum thickness of shell plates in weakest course, in.

E = efficiency of longitudinal joint or of ligaments between tube holes (whichever is the least)

R = inside radius of the weakest course of the shell or drum, in.

FS = factor of safety, or the ratio of the ultimate strength of the material to the allowable stress. For new constructions covered in Part I, FS in the above formula = 5.

BOILER JOINTS

181 *Efficiency of a Joint.* The efficiency of a joint is the ratio which the strength of the joint bears to the strength of the solid plate. In the case of a riveted joint this is determined by calculating the breaking strength of a unit section of the joint, considering each possible mode of failure separately, and dividing the lowest result by the breaking strength of the solid plate of a length equal to that of the section considered. (See Appendix, Par. 410 to 416, for detailed methods and examples.)

182 The distance between the center lines of any two adjacent rows of rivets, or the "back pitch" measured at right angles to the direction of the joint, shall be at least twice the diameter of the rivets and shall also meet the following requirements:

a Where each rivet in the inner row comes midway between two rivets in the outer row, the sum of the two diagonal sections of the plate between the inner rivet and the two outer rivets shall be at least 20 per cent greater than the section of the plate between the two rivets in the outer row.

b Where two rivets in the inner row come between two rivets in the outer row, the sum of the two diagonal sections of the plate between the two inner rivets and the two rivets in the outer row shall be at least 20 per cent greater than the difference in the section of the plate between the two rivets in the outer row and the two rivets in the inner row.

183 On longitudinal joints, the distance from the centers of rivet holes to the edges of the plates, except rivet holes in the ends of butt straps, shall be not less than one and one-half times the diameter of the rivet holes.

184 *a Circumferential Joints.* The strength of circumferential joints of boilers, the heads of which are not stayed by tubes or through braces shall be at least 50 per cent that of the longitudinal joints of the same structure.

b When 50 per cent or more of the load which would act on an unstayed solid head of the same diameter as the shell, is relieved by the effect of tubes or through stays, in consequence of the reduction of the area acted on by the pressure and the holding power of the tubes and stays, the strength of the circumferential joints in the shell shall be at least 35 per cent that of the longitudinal joints.

185 When shell plates exceed 9/16 in. in thickness in horizontal

return tubular boilers, the portion of the plates forming the laps of the circumferential joints, where exposed to the fire or products of combustion, shall be planed or milled down as shown in Fig. 8, to $\frac{1}{2}$ in. in thickness, provided the requirement in Par. 184 is complied with.

186 *Welded Joints.* The ultimate tensile strength of a longitudinal joint which has been properly welded by the forging process, shall be taken as 28,500 lb. per sq. in., with steel plates having a range in tensile strength of 47,000 to 55,000 lb. per sq. in.

187 *Longitudinal Joints.* The longitudinal joints of a shell or drum which exceeds 36 in. in diameter, shall be of butt and double-strap construction.

188 The longitudinal joints of a shell or drum which does not

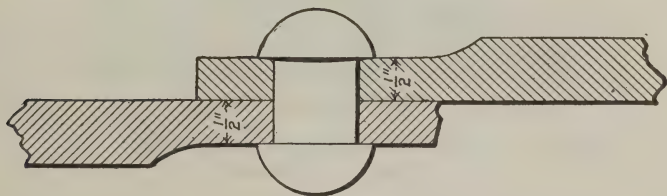


FIG. 8 CIRCUMFERENTIAL JOINT FOR THICK PLATES OF HORIZONTAL RETURN TUBULAR BOILERS

exceed 36 in. in diameter, may be of lap-riveted construction; but the maximum allowable working pressure shall not exceed 100 lb. per sq. in.

189 The longitudinal joints of horizontal return tubular boilers shall be located above the fire-line of the setting.

190 A horizontal return tubular boiler on which a longitudinal lap joint is permitted shall not have a course over 12 ft. in length. With butt and double-strap construction, longitudinal joints of any length may be used provided the plates are tested transversely to the direction of rolling, which tests shall show the standards prescribed under the Specifications of Boiler Plate Steel.

191 Butt straps and the ends of shell plates forming the longitudinal joints shall be rolled or formed by pressure, not blows, to the proper curvature.

LIGAMENTS

192 *Efficiency of Ligament.* When a shell or drum is drilled for tubes in a line parallel to the axis of the shell or drum, the efficiency of the ligament between the tube holes shall be determined as follows:

- a When the pitch of the tube holes on every row is equal (Fig. 9), the formula is:

$$\frac{p-d}{p} = \text{efficiency of ligament}$$

where

p = pitch of tube holes, in.

d = diameter of tube holes, in.

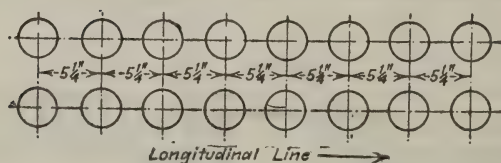


FIG. 9 EXAMPLE OF TUBE SPACING WITH PITCH OF HOLES EQUAL IN EVERY ROW

Example: Pitch of tube holes in the drum as shown in Fig. 9 = $5\frac{1}{4}$ in. Diameter of tubes = $3\frac{1}{4}$ in. Diameter of tube holes = $3\frac{9}{32}$ in.

$$\frac{p-d}{p} = \frac{5.25-3.281}{5.25} = 0.375, \text{ efficiency of ligament}$$

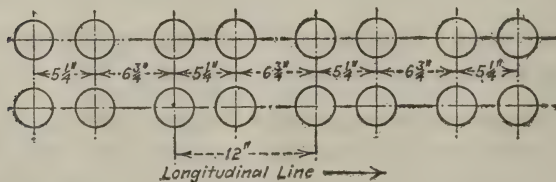


FIG. 10 EXAMPLE OF TUBE SPACING WITH PITCH OF HOLES UNEQUAL IN EVERY SECOND ROW

- b When the pitch of tube holes on any one row is unequal (as in Figs. 10 or 11), the formula is:

$$\frac{p-n d}{p} = \text{efficiency of ligament}$$

where

p = unit length of ligament, in.

n = number of tube holes in length, p .

d = diameter of tube holes, in.

Example: Spacing shown in Fig. 10. Diameter of tube holes = $3\frac{9}{32}$ in.

$$\frac{p - n d}{p} = \frac{12 - 2 \times 3.281}{12} = 0.453, \text{ efficiency of ligament}$$

Example: Spacing shown in Fig. 11. Diameter of tube holes = $3\frac{9}{32}$ in.

$$\frac{p - n d}{p} = \frac{29.25 - 5 \times 3.281}{29.25} = 0.439, \text{ efficiency of ligament}$$

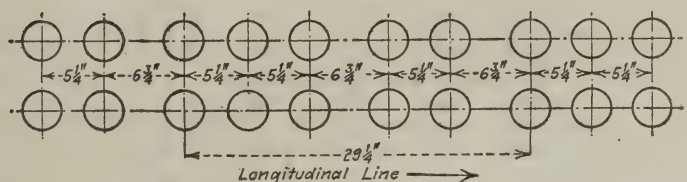


FIG. 11 EXAMPLE OF TUBE SPACING WITH PITCH OF HOLES VARYING IN EVERY SECOND AND THIRD ROW

193 When a shell or drum is drilled for tube holes in a line diagonal with the axis of the shell or drum as shown in Fig. 12, the efficiency of the ligament between the tube holes shall be determined by the following methods and the lowest value used.

$$a \quad \frac{0.95(p_1 - d)}{p_1} = \text{efficiency of ligament}$$

$$b \quad \frac{p - d}{p} = \text{efficiency of ligament}$$

where

p_1 = diagonal pitch of tube holes, in.

d = diameter of tube holes, in.

p = longitudinal pitch of tube holes or distance between centers of tubes in a longitudinal row, in.

The constant 0.95 in formula a applies provided $\frac{p_1}{d}$ is 1.5 or over.

Example: Diagonal pitch of tube holes in drum as shown in Fig. 12 = 6.42 in.

Diameter of tube holes = $4 \frac{1}{32}$ in.

Longitudinal pitch of tube holes = $11 \frac{1}{2}$ in.

$$a \quad \frac{0.95(6.42 - 4.031)}{6.42} = 0.353, \text{ efficiency of ligament}$$

$$b \quad \frac{11.5 - 4.031}{11.5} = 0.649, \text{ efficiency of ligament}$$

The value determined by formula *a* is the least and is the one that shall be used in this case.

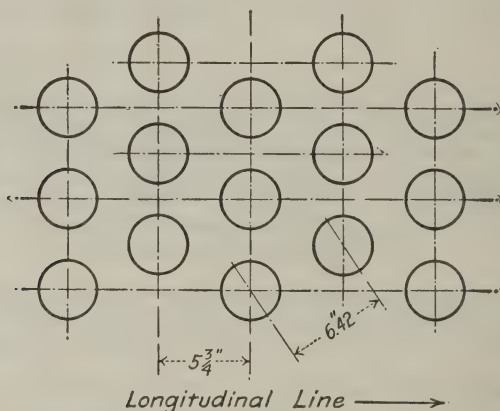


FIG. 12 EXAMPLE OF TUBE SPACING WITH TUBE HOLES ON DIAGONAL LINES

194 *Domes.* The longitudinal joint of a dome 24 in. or over in diameter shall be of butt and double-strap construction, and its flange shall be double riveted to the boiler shell when the maximum allowable working pressure exceeds 100 lb. per sq. in.

The longitudinal joint of a dome less than 24 in. in diameter may be of the lap type, and its flange may be single riveted to the boiler shell provided the maximum allowable working pressure on such a dome is computed with a factor of safety of not less than 8.

The dome may be located on the barrel or over the fire-box on traction, portable or stationary boilers of the locomotive type up to and including 48 in. barrel diameter. For larger barrel diameters, the dome shall be placed on the barrel.

DISHED HEADS

195 *Convex Heads.* The thickness required in an unstayed dished head with the pressure on the concave side, when it is a segment of a sphere, shall be calculated by the following formula:

$$t = \frac{5.5 \times P \times L}{2 \times TS} + \frac{1}{8}$$

where

t = thickness of plate, in.

P = maximum allowable working pressure, lb. per sq. in.

TS = tensile strength, lb. per sq. in.

L = radius to which the head is dished, in.

Where the radius is less than 80 per cent of the diameter of the shell or drum to which the head is attached the thickness shall be at least that found by the formula by making L equal to 80 per cent of the diameter of the shell or drum.

Concave Heads. Dished heads with the pressure on the convex side shall have a maximum allowable working pressure equal to 60 per cent of that for heads of the same dimensions with the pressure on the concave side.

When a dished head has a manhole opening, the thickness as found by these Rules shall be increased by not less than $\frac{1}{8}$ in.

196 When dished heads are of a less thickness than called for by Par. 195, they shall be stayed as flat surfaces, no allowance being made in such staying for the holding power due to the spherical form.

197 The corner radius of an unstayed dished head measured on the concave side of the head shall not be less than $1\frac{1}{2}$ in. or more than 4 in. and within these limits shall be not less than 3 per cent of L in Par. 195.

198 A manhole opening in a dished head shall be flanged to a depth of not less than three times the thickness of the head measured from the outside.

BRACED AND STAYED SURFACES

199 The maximum allowable working pressure for various thicknesses of braced and stayed flat plates and those which by these Rules require staying as flat surfaces with braces or staybolts of uni-

form diameter symmetrically spaced, shall be calculated by the formula:

$$P = C \times \frac{t^2}{p^2}$$

where

P = maximum allowable working pressure, lb. per sq. in.

t = thickness of plate in *sixteenths* of an inch

P = maximum pitch measured between straight lines passing through the centers of the staybolts in the different rows, which lines may be horizontal, vertical or inclined, in.

$C = 112$ for stays screwed through plates not over $7/16$ in. thick with ends riveted over

$C = 120$ for stays screwed through plates over $7/16$ in. thick with ends riveted over

$C = 135$ for stays screwed through plates and fitted with single nuts outside of plate

$C = 175$ for stays fitted with inside and outside nuts and outside washers where the diameter of washers is not less than $0.4p$ and thickness not less than t .

If flat plates not less than $3/8$ in. thick are strengthened with doubling plates securely riveted thereto and having a thickness of not less than $2/3 t$, nor more than t , then the value of t in the formula shall be $3/4$ of the combined thickness of the plates and the values of C given above may also be increased 15 per cent.

200 *Staybolts.* The ends of screwed staybolts shall be riveted over or upset by equivalent process. The outside ends of such staybolts shall be drilled with a hole at least $3/16$ in. diameter to a depth extending $1/2$ in. beyond the inside of the plates, except on boilers having a grate area not exceeding 15 sq. ft., where the drilling of the staybolts is optional.

201 When channel irons or other members are securely riveted to the boiler heads for attaching through stays the transverse stress on such members shall not exceed 12,500 lb. per sq. in. In computing the stress, the section modulus of the member shall be used without addition for the strength of the plate. The spacing of the rivets over the supported surface shall be in conformity with that specified for staybolts.

202 The ends of stays fitted with nuts shall not be exposed to the direct radiant heat of the fire.

203 The maximum spacing between centers of rivets attaching the crowfeet of braces to the braced surface, shall be determined by the formula in Par. 199, using 135 for value of C .

The maximum spacing between the inner surface of the shell and lines parallel to the surface of the shell passing through the centers of the rivets attaching the crowfeet of braces to the head, shall be determined by the formula in Par. 199, using 160 for the value of C .

TABLE 3 MAXIMUM ALLOWABLE PITCH, IN INCHES, OF SCREWED STAYBOLTS, ENDS RIVETED OVER

Pressure, Lb. per Sq. In.	Thickness of Plate, In.						
	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$
	Maximum Pitch of Staybolts, In.						
100	5¼	6¾	7¾	.....	.....	.....	.....
110	5	6	7	8¾	.....	.....	.....
120	4¾	5¾	6¾	8	.....	.....	.....
125	4¾	5¾	6¾	7¾	.....	.....	.....
130	4¾	5½	6½	7½	.....	.....	.....
140	4½	5¾	6¼	7¾	8¾	.....	.....
150	4¼	5½	6	7½	8	.....	.....
160	4½	5	5¾	6¾	7¾	.....	.....
170	4	4¾	5¾	6¾	7½	8¾	.....
180	.....	4¾	5½	6½	7¾	8¾	.....
190	.....	4¾	5¾	6¾	7¾	7¾	.....
200	.....	4½	5¼	6½	7	7¾	8½
225	.....	4¼	4¾	5¾	6½	7¼	8
250	.....	4	4¾	5½	6¼	6¾	7½
300	.....	.....	4¼	5	5¾	6¼	7

204 The formula in Par. 199 was used in computing Table 3. Where values for screwed stays with ends riveted over are required for conditions not given in Table 3, they may be computed from the formula and used, provided the pitch does not exceed 8½ in.

205 The distance from the edge of a staybolt hole to a straight line tangent to the edges of the rivet holes may be substituted for p for staybolts adjacent to the riveted edges bounding a stayed surface. When the edge of a stayed plate is flanged, p shall be measured from the inner surface of the flange, at about the line of rivets to the edge of the staybolts or to the projected edge of the staybolts.

206 The distance between the edges of the staybolt holes may be substituted for p for staybolts adjacent to a furnace door or other boiler fitting, tube hole, hand hole or other opening.

207 In water leg boilers, the staybolts may be spaced at greater distances between the rows than indicated in Table 3, provided the portions of the sheet which come between the rows of staybolts have the proper transverse strength to give a factor of safety of at least 5 at the maximum allowable working pressure.

208 The diameter of a screw stay shall be taken at the bottom of the thread, provided this is the least diameter.

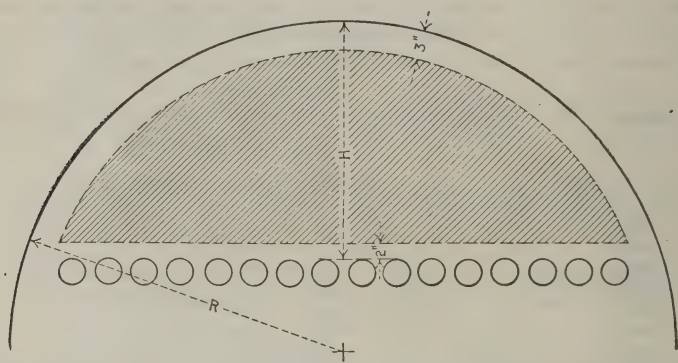


FIG. 13 METHOD OF DETERMINING NET AREA OF SEGMENT OF A HEAD

209 The least cross-sectional area of a stay shall be taken in calculating the allowable stress, except that when the stays are welded and have a larger cross-sectional area at the weld than at some other point, in which case the strength at the weld shall be computed as well as in the solid part and the lower value used.

210 Holes for screw stays shall be drilled full size or punched not to exceed $\frac{1}{4}$ in. less than full diameter of the hole for plates over $\frac{5}{16}$ in. in thickness, and $\frac{1}{8}$ in. less than the full diameter of the hole for plates not exceeding $\frac{5}{16}$ in. in thickness, and then drilled or reamed to the full diameter. The holes shall be tapped fair and true, with a full thread.

211 The ends of steel stays upset for threading, shall be thoroughly annealed.

212 An internal cylindrical furnace which requires staying shall be stayed as a flat surface as indicated in Table 3.

213 *Staying Segments of Heads.* A segment of a head shall be stayed by head to head, through, diagonal, crowfoot or gusset stays, except that a horizontal return tubular boiler may be stayed as provided in Pars. 225 to 229.

214 *Areas of Segments of Heads to be Stayed.* The area of a segment of a head to be stayed shall be the area enclosed by lines drawn 3 in. from the shell and 2 in. from the tubes, as shown in Figs. 13 and 14.

215 In water tube boilers, the tubes of which are connected to drum heads, the area to be stayed shall be taken as the total area of the head less a 5 in. annular ring, measured from the inner circumference of the drum shell.

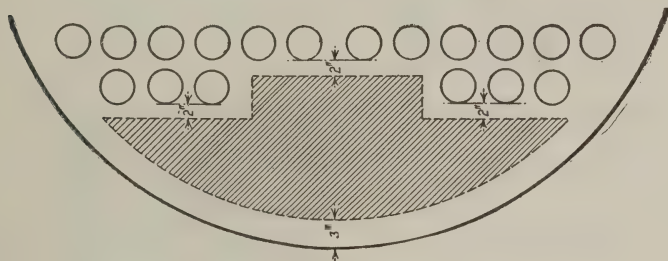


FIG. 14. METHOD OF DETERMINING NET AREA OF IRREGULAR SEGMENT OF A HEAD

When such drum heads are 30 in. or less in diameter and the tube plate is stiffened by flanged ribs or gussets, no stays need be used if a hydrostatic test to destruction of a boiler or unit section built in accordance with the construction, shows that the factor of safety is at least 5.

216 In a fire tube boiler, stays shall be used in the tube sheets if the distances between the edges of the tube holes exceed the maximum pitch of staybolts given in Table 3. That part of the tube sheet which comes between the tubes and the shell, need not be stayed when the distance from the inside of the shell to the outer surface of the tubes does not exceed that given by the formula in Par. 199, using 160 for the value of C .

217 The net area to be stayed in a segment of a head may be determined by the following formula:

$$\frac{4}{3} \frac{(H-5)^2}{\sqrt{\frac{2}{(H-5)} \left(\frac{R-3}{(H-5)} \right)}} - 0.608 = \text{area to be stayed, sq. in.}$$

where

H = distance from tubes to shell, in.

R = radius of boiler head, in.

218 When the portion of the head below the tubes in a horizontal return tubular boiler is provided with a manhole opening, the flange of which is formed from the solid plate and turned inward to a depth of not less than three times the thickness of the head, measured from the outside, the area to be stayed as indicated in Fig. 14, may be reduced by 100 sq. in. The surface around the manhole shall be supported by through stays with nuts inside and outside at the front head.

TABLE 4 MAXIMUM ALLOWABLE STRESSES FOR STAYS AND STAYBOLTS

Description of Stays	Stresses, Lb. per Sq. In.	
	For Lengths between Supports not Exceeding 120 Diameters	For Lengths between Supports Exceeding 120 Diameters
<i>a</i> Unwelded stays less than twenty diameters long screwed through plates with ends riveted over.	7500	....
<i>b</i> Unwelded stays and unwelded portions of welded stays, except as specified in line <i>a</i> .	9500	8500
<i>c</i> Welded portions of stays.	6000	6000

219 When stay rods are screwed through the sheets and riveted over, they shall be supported at intervals not exceeding 6 ft. In boilers without manholes, stay rods over 6 ft. in length may be screwed through the sheets and fitted with nuts and washers on the outside.

220 The maximum allowable stress per square inch net cross sectional area of stays and staybolts shall be as given in Table 4.

The length of the stay between supports shall be measured from the inner faces of the stayed plates. The stresses are based on tension only. For computing stresses in diagonal stays, see Pars. 221 and 222.

221 *Stresses in Diagonal and Gusset Stays.* Multiply the area of a direct stay required to support the surface by the slant or diagonal

length of the stay; divide this product by the length of a line drawn at right angles to surface supported to center of palm of diagonal stay. The quotient will be the required area of the diagonal stay.

$$A = \frac{a \times L}{l}$$

where

A = sectional area of diagonal stay, sq. in.

a = sectional area of direct stay, sq. in.

L = length of diagonal stay, as indicated in Fig. 15, in.

l = length of line drawn at right angles to boiler head or surface supported to center of palm of diagonal stay, as indicated in Fig. 15, in.

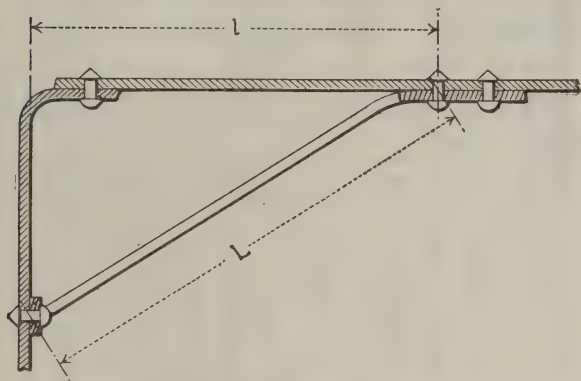


FIG. 15 MEASUREMENTS FOR DETERMINING STRESSES IN DIAGONAL STAYS

Given diameter of direct stay = 1 in., $a = 0.7854$, $L = 60$ in.,

$l = 48$ in.; substituting and solving:

$$A = \frac{0.7854 \times 60}{48} = 0.981 \text{ sectional area, sq. in.}$$

Diameter = 1.11 in. = $1\frac{1}{8}$ in.

222 For staving segments of tube sheets such as in horizontal return tubular boilers, where L is not more than 1.15 times l for any brace, the stays may be calculated as direct stays, allowing 90 per cent of the stress given in Table 4.

223 *Diameter of Pins and Area of Rivets in Brace.* The sectional area of pins to resist double shear and bending when secured in crowfoot, sling, and similar stays shall be at least equal to three-

fourths of the required cross-sectional area of the brace. The combined cross section of the eye at the sides of the pin shall be at least 25 per cent greater than the required cross-sectional area of the brace.

The cross-sectional area of the rivets attaching a brace to the shell or head shall be not less than one and one quarter times the required sectional area of the brace. Each branch of a crowfoot shall be designed to carry two-thirds of the total load on the brace. The net sectional areas through the sides of the crowfeet, tee irons or similar fastenings at the rivet holes shall be at least equal to the required rivet section. All rivet holes shall be drilled and burrs removed, and the pins shall be made a neat fit.

TABLE 5 SIZES OF ANGLES REQUIRED FOR STAYING SEGMENTS OF HEADS

With the short legs of the angles attached to the head of the boiler

Height of Segment, Dimension B in Fig. 16	30" Boiler			34" Boiler			36" Boiler			Dimension A in Fig. 16
	Angle 3"x2½"	Angle 3½"x3"	Angle 4"x3"	Angle 3½"x3"	Angle 4"x3"	Angle 5"x3"	Angle 4"x3"	Angle 5"x3"	Angle 6"x3½"	
	Thick-ness, inches	Thick-ness, inches	Thick-ness, inches	Thick-ness, inches	Thick-ness, inches	Thick-ness, inches	Thick-ness, inches	Thick-ness, inches	Thick-ness, inches	
10	¾	⅞	⅞	—	—	—	—	—	—	6½
11	⅞	¾	⅞	⅞	⅞	⅞	—	—	—	7
12	⅞	⅞	¾	½	⅞	⅞	⅞	⅞	—	7½
13	—	⅞	⅞	⅞	½	⅞	⅞	¾	—	8
14	—	—	½	—	¾	¾	¾	⅞	¾	8½
15	—	—	—	—	—	½	¾	½	¾	9
16	—	—	—	—	—	—	—	¾	⅞	9½

224 Gusset stays when constructed of triangular right-angled web plates secured to single or double angle bars along the two sides at right angles shall have a cross-sectional area (in a plane at right angles to the longest side and passing through the intersection of the two shorter sides) not less than 10 per cent greater than would be required for a diagonal stay to support the same surface, figured by the formula in Par. 221, assuming the diagonal stay is at the same angle as the longest side of the gusset plate.

225 *Staying of Upper Segments of Tube Heads by Steel Angles.* When the shell of a boiler does not exceed 36 in. in diameter and is designed for a maximum allowable working pressure not exceeding 100 lb. per sq. in., the segment of heads above the tubes *may* be stayed by steel angles as specified in Table 5 and Fig. 16, except that angles of

equal thickness and greater depth of outstanding leg, or of greater thickness and the same depth of outstanding leg, may be substituted for those specified. The legs attached to the heads may vary in depth $\frac{1}{2}$ in. above or below the dimensions specified in Table 5.

226 When this form of bracing is to be placed on a boiler, the diameter of which is intermediate to or below the diameters given in Table 5, the tabular values for the next higher diameter shall govern. Rivets of the same diameter as used in the longitudinal seams of the boiler shall be used to attach the angles to the head and to connect the outstanding legs.

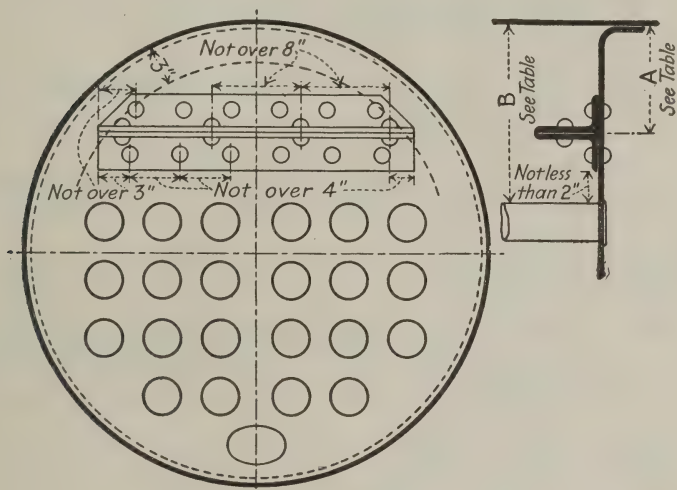


FIG. 16 STAYING OF HEAD WITH STEEL ANGLES IN TUBULAR BOILER

227 The rivets attaching angles to heads shall be spaced not over 4 in. apart. The centers of the end rivets shall be not over 3 in. from the ends of the angle. The rivets through the outstanding legs shall be spaced not over 8 in. apart; the centers of the end rivets shall be not more than 4 in. from the ends of the angles. The ends of the angles shall be considered those of the outstanding legs and the lengths shall be such that their ends overlap a circle 3 in. inside the inner surface of the shell as shown in Fig. 16.

228 The distance from the center of the angles to the shell of the boiler, marked *A* in Fig. 16, shall not exceed the values given in Table 5, but in no case shall the leg attached to the head on the lower angle come closer than 2 in. to the top of the tubes.

229 When segments are beyond the range specified in Table 5, the heads shall be braced or stayed in accordance with the requirements in these Rules.

230 *Crown Bars and Girder Stays.* Crown bars and girder stays for tops of combustion chambers and back connections, or wherever used, shall be proportioned to conform to the following formula:

$$\text{Maximum allowable working pressure} = \frac{C \times d^2 \times T}{(W - P) \times D \times W}$$

where

W = extreme distance between supports, in.

P = pitch of supporting bolts, in.

D = distance between girders from center to center, in.

d = depth of girder, in.

T = thickness of girder, in.

C = 7000 when the girder is fitted with one supporting bolt

C = 10,000 when the girder is fitted with two or three supporting bolts

C = 11,000 when the girder is fitted with four or five supporting bolts

C = 11,500 when the girder is fitted with six or seven supporting bolts

C = 12,000 when the girder is fitted with eight or more supporting bolts

Example: Given $W = 34$ in., $P = 7.5$ in., $D = 7.75$ in., $d = 7.5$ in., $T = 2$ in.; three stays per girder, $C = 10,000$; then substituting in formula:

Maximum allowable working pressure =

$$\frac{10,000 \times 7.5 \times 7.5 \times 2}{(34 - 7.5) \times 7.75 \times 34} = 161.1 \text{ lb. per sq. in.}$$

231 *Maximum Allowable Working Pressure on Truncated Cones.* Upper combustion chambers or vertical submerged tubular boilers made in the shape of a frustum of a cone when not over 38 in. diameter at the large end, may be used without stays if figured by the rule for plain cylindrical furnaces (Par. 239) making D in the formula equal to the diameter at the large end. When over 38 in. in diameter, that portion over 30 in. in diameter shall be fully supported by staybolts or gussets to conform to the provisions for the staying of flat surfaces.

232 *Stay Tubes.* When stay tubes are used in multitubular

boilers to give support to the tube plates, the sectional area of such stay tubes may be determined as follows:

$$\text{Total section of stay tubes, sq. in.} = \frac{(A-a) P}{T}$$

where

A = area of that portion of the tube plate containing the tubes, sq. in.

a = aggregate area of holes in the tube plate, sq. in.

• P = maximum allowable working pressure, lb. per sq. in.

T = working tensile stress allowed in the tubes, not to exceed 7000 lb. per sq. in.

233 The pitch of stay tubes shall conform to the formula given in Par. 199, using the values of C as given in Table 6.

TABLE 6. VALUES OF C FOR DETERMINING PITCH OF STAY TUBES.

Pitch of Stay Tubes in the Bounding Rows	When tubes have no Nuts Outside of Plates	When tubes are Fitted with Nuts Outside of Plates
Where there are two plain tubes between each stay tube.	120	130
Where there is one plain tube between each stay tube.	140	150
Where every tube in the bounding rows is a stay tube and each alternate tube has a nut. . . . .	....	170

When the ends of tubes are not shielded from the action of flame or radiant heat, the values of C shall be reduced 20 per cent. The tubes shall project about $\frac{1}{4}$ in. at each end and be slightly flared. Stay tubes when threaded shall not be less than $\frac{3}{16}$ in. thick at bottom of thread; nuts on stay tubes are not advised. For a nest of tubes C shall be taken as 140 and S as the mean pitch of stay tubes. For spaces between nests of tubes S shall be taken as the horizontal distance from center to center of the bounding rows of tubes and C as given in Table 6.

TUBE SHEETS OF COMBUSTION CHAMBERS

234 The maximum allowable working pressure on a tube sheet of a combustion chamber, where the crown sheet is not suspended from the shell of the boiler, shall be determined by the following formula:

$$P = \frac{(D-d) T \times 27,000}{W \times D}$$

where

P = maximum allowable working pressure, lb. per sq. in.

D = least horizontal distance between tube centers, in.

d = inside diameter of tubes, in.

T = thickness of tube plate, in.

W = distance from tube sheet to opposite combustion chamber sheet, in.

Example: Required the working pressure of a tube sheet supporting a crown sheet braced by crown bars. Horizontal distance between centers, $4\frac{1}{8}$ in.; inside diameter of tubes, 2.782 in.; thickness of tube sheets, $\frac{11}{16}$ in.; distance from tube sheet to opposite combustion chamber sheet, $34\frac{1}{4}$ in., measured from outside of tube plate to outside of back plate; material, steel. Substituting and solving:

$$P = \frac{(4.125 - 2.782) \times 0.6875 \times 27,000}{34.25 \times 4.125} = 176 \text{ lb. per sq. in.}$$

235 Sling stays may be used in place of girders in all cases covered in Par. 234, provided, however, that when such sling stays are

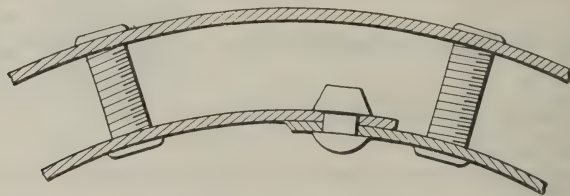


FIG. 17 PROPER LOCATION OF STAYBOLTS ADJACENT TO LONGITUDINAL JOINT IN FURNACE SHEET

used, girders or screw stays of the same sectional area shall be used for securing the bottom of the combustion chamber to the boiler shell.

236 When girders are dispensed with and the top and bottom of combustion chambers are secured by sling stays or braces, the sectional area of such stays shall conform with the requirements of rules for stays and stayed surfaces.

237 *Furnaces of Vertical Boilers.* In a vertical fire-tube boiler the furnace length, for the purpose of calculating its strength and spacing staybolts over its surface, shall be measured from the center of rivets in the bottom of the water-leg to the center of rivets in the flange of the lower tube sheet.

238 When the longitudinal joint of the furnace sheet of a vertical fire-tube boiler is of lap-riveted construction and staybolted, a staybolt in each circular row shall be located near the longitudinal joint, as shown in Fig. 17.

239 *Plain Circular Furnaces.* The maximum allowable working pressure for unstayed, riveted, seamless or lap welded furnaces, where the length does not exceed 6 times the diameter and where the thickness is at least 5/16 in. shall be determined by one or the other of the following formulae:

- a Where the length does not exceed 120 times the thickness of the plate

$$P = \frac{51.5}{D} \left\{ (18.75 \times T) - (1.03 \times L) \right\}$$

- b Where the length exceeds 120 times the thickness of the plate

$$P = \frac{4250 \times T^2}{L \times D}$$

where

P = maximum allowable working pressure, lb. per sq. in.

D = outside diameter of furnace, in.

L = length of furnace, in.

T = thickness of furnace walls, in sixteenths of an inch.

Where the furnaces have riveted longitudinal joints no deduction need be made for the joint provided the efficiency of the joint is greater than $P \times D$ divided by $1,250 \times T$.

Example. Given a furnace 26 in. in diameter, 94 in. long and 1/2 in. thick. The length exceeds 120 times the thickness of the plate, hence the formula (b) should be used. Substituting the values in this formula:

$$P = \frac{4250 \times 8 \times 8}{94 \times 26} = 111 \text{ lb. per sq. in.}$$

240 A plain cylindrical furnace exceeding 38 in. in diameter shall be stayed in accordance with the rules governing flat surfaces.

241 *Circular Flues.* The maximum allowable working pressure for seamless or welded flues more than 5 in. in diameter and up to and including 18 in. in diameter shall be determined by one or the other of the following formulae:

- a Where the thickness of the wall is less than 0.023 times the diameter

$$P = \frac{10,000,000 \times T^3}{D^3}$$

- b Where the thickness of the wall is greater than 0.023 times the diameter

$$P = \frac{17,300 \times T}{D} - 275$$

where

P = maximum allowable working pressure, lb. per sq. in.

D = outside diameter of flue, in.

T = thickness of wall of flue, in.

- c The above formulae may be applied to riveted flues of the sizes specified provided the sections are not over 3 ft. in length and provided the efficiency of the joint is greater than $P \times D$ divided by $20,000 \times T$.

Example. Given a flue 14 in. in diameter and 5/16 in. thick. The thickness of the wall is less than 0.023 times the diameter; hence the formula (a) should be used. Substituting the values in this formula:

$$P = \frac{10,000,000 \times 5/16 \times 5/16 \times 5/16}{14 \times 14 \times 14} = 110 \text{ lb. per sq. in.}$$

242 *Adamson Type.* When plain horizontal flues are made in sections not less than 18 in. in length, and not less than 5/16 in. thick:

a They shall be flanged with a radius measured on the fire side, of not less than three times the thickness of the plate, and the flat portion of the flange outside of the radius shall be at least three times the diameter of the rivet holes.

b The distance from the edge of the rivet holes to the edge of the flange shall be not less than the diameter of the rivet hole, and the diameter of the rivets before driving shall be at least 1/4 in. larger than the thickness of the plate.

c The depth of the Adamson ring between the flanges shall be not less than three times the diameter of the rivet holes, and the ring shall be substantially riveted to the flanges. The fire edge of the ring shall terminate at or about the point of tangency to the curve of the flange, and the thickness of the ring shall be not less than 1/2 in.

The maximum allowable working pressure shall be determined by the following formula:

$$P = \frac{57.6}{D} \left\{ (18.75 \times T) - (1.03 \times L) \right\}$$

where

P = maximum allowable working pressure, lb. per sq. in.

D = outside diameter of furnace, in.

L = length of furnace section, in.

T = thickness of plate, in sixteenths of an inch.

Example. Given a furnace 44 in. in diameter, 48 in. in length, and 1/2 in. thick. Substituting values in formula:

$$P = \frac{57.6}{44} \left\{ (18.75 \times 8) - (1.03 \times 48) \right\}$$

$$= 1.309 (150 - 49.44) = 131 \text{ lb. per sq. in.}$$

243 The maximum allowable working pressure on corrugated furnaces, such as the Leeds suspension bulb, Morison, Fox, Purves, or Brown, having plain portions at the ends not exceeding 9 in. in length (except flues especially provided for) when new and practically circular, shall be computed as follows:

$$P = \frac{C \times T}{D}$$

where

P = maximum allowable working pressure, lb. per sq. in.

T = thickness, in.—not less than $5/16$ in. for Leeds, Morison, Fox and Brown, and not less than $7/16$ in. for Purves and other furnaces corrugated by sections not over 18 in. long.

D = mean diameter, in.

$C = 17,300$, a constant for *Leeds furnaces*, when corrugations are not more than 8 in. from center to center and not less than $2\frac{1}{4}$ in. deep.

$C = 15,600$, a constant for *Morison furnaces*, when corrugations are not less than 8 in. from center to center and the radius of the outer corrugations is not more than one half that of the suspension curve.

$C = 14,000$, a constant for *Fox Furnaces*, when corrugations are not more than 8 in. from center to center and not less than $1\frac{1}{2}$ in. deep.

$C = 14,000$, a constant for *Purves furnaces* when rib projections are not more than 9 in. from center to center and not less than $1\frac{3}{8}$ in. deep.

$C = 14,000$, a constant for *Brown Furnaces*, when corrugations are not more than 9 in. from center to center and not less than $1\frac{5}{8}$ in. deep.

$C = 10,000$, a constant for furnaces corrugated by sections not more than 18 in. from center to center and not less than $2\frac{1}{2}$ in. deep, measured from the least inside to the greatest outside diameter of the corrugations, and having the ends fitted one into the other and substantially riveted together, provided that the plain parts at the ends do not exceed 12 in. in length.

In calculating the mean diameter of the Morison furnace, the least inside diameter plus 2 in., may be taken as the mean diameter.

244 The thickness of a corrugated or ribbed furnace shall be ascertained by actual measurement. The furnace shall be drilled for a $\frac{1}{4}$ -in. pipe tap and fitted with a screw plug that can be removed for the purpose of measurement. For the Brown and Purves furnaces, the holes shall be in the center of the second flat; for the Morison, Fox and other similar types, in the center of the top corrugation, at least as far in as the fourth corrugation from the end of the furnace.

245 *Cast Iron Headers.* The pressure allowed on a water-tube boiler, the tubes of which are secured to cast-iron or malleable-iron headers, shall not exceed 160 lb. per sq. in. The form and size of the internal cross section of a cast-iron or malleable-iron header at any point shall be such that it will fall within a 6 in. by 7 in. rectangle.

246 The cast-iron used for the headers of water-tube boilers shall conform with the Specifications for Gray-iron Castings given in Pars. 95 to 110, the header to be arbitrarily classified as a "medium casting" as to physical properties and tests, and as a "light casting" as to chemical properties.

247 A cast-iron header when tested to destruction, shall withstand a hydrostatic pressure of at least 1200 lb. per sq. in. A hydrostatic test at 400 lb. per sq. in. gage pressure shall be made on all new headers with tubes attached.

TUBES

248 *Tube Holes and Ends.* Tube holes shall be drilled full size from the solid plate, or they may be punched at least $\frac{1}{2}$ in. smaller in diameter than full size, and then drilled, reamed or finished full size with a rotating cutter.

249 The sharp edges of tube holes shall be taken off on both sides of the plate with a file or other tool.

250 A fire-tube boiler shall have the ends of the tubes substantially rolled and beaded, or welded at the firebox or combustion chamber end.

251 The ends of all tubes, suspension tubes and nipples shall be flared not less than $\frac{1}{8}$ in. over the diameter of the tube hole on all water-tube boilers and superheaters, or they may be beaded.

252 The ends of all tubes, suspension tubes and nipples of water-tube boilers and superheaters shall project through the tube sheets or headers not less than $\frac{1}{4}$ in. nor more than $\frac{1}{2}$ in. before flaring.

RIVETING

253 *Riveting.* Rivet holes, except for attaching stays or angle bars to heads, shall be drilled full size with plates, butt straps and heads bolted in position; or they may be punched not to exceed $\frac{1}{4}$ in. less than full diameter for plates over $\frac{5}{16}$ in. in thickness, and $\frac{1}{8}$ in. less than full diameter for plates not exceeding $\frac{5}{16}$ in. in thickness, and then drilled or reamed to full diameter with plates, butt straps and heads bolted in position.

254 After drilling rivet holes, the plates and butt straps shall be separated and the burrs removed.

255 *Rivets.* Rivets shall be of sufficient length to completely fill the rivet holes and form heads at least equal in strength to the bodies of the rivets.

256 Rivets shall be machine driven wherever possible, with sufficient pressure to fill the rivet holes, and shall be allowed to cool and shrink under pressure.

CALKING

257 *Calking.* The calking edges of plates, butt straps and heads shall be beveled. Every portion of the calking edges of plates, butt straps and heads shall be planed, milled or chipped to a depth of not less than $\frac{1}{8}$ in. Calking shall be done with a round-nosed tool.

MANHOLES

258 *Manholes.* An elliptical manhole opening shall be not less than 11×15 in. or 10×16 in. in size. A circular manhole opening shall be not less than 15 in. in diameter.

259 A manhole reinforcing ring when used, shall be of steel or wrought-iron, and shall be at least as thick as the shell plate.

260 Manhole frames on shells or drums when used, shall have the proper curvature, and on boilers over 48 in. in diameter shall be riveted to the shell or drum with two rows of rivets, which may be pitched as shown in Fig. 18. The strength of the rivets in shear on manhole frames and reinforcing rings shall be at least equal to the tensile strength of that part of the shell plate removed, on a line parallel to the axis of the shell, through the center of the manhole, or other opening.

261 The proportions of manhole frames and other reinforcing rings to conform to the above specifications may be determined by the use of the following formulae, which are based on the assumption that the rings shall have the same tensile strength per square inch of section as, and be of not less thickness than, the shell plate removed.

For a single-riveted ring: $W = \frac{l \times t_1}{2 \times t} + d$

For a double-riveted ring: $W = \frac{l \times t_1}{2 \times t} + 2d$

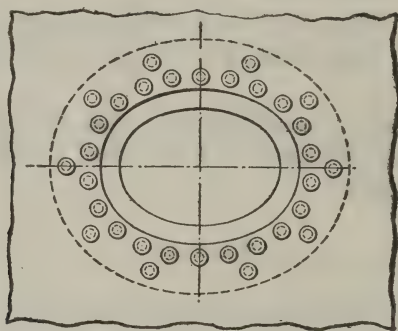


FIG. 18 METHOD OF RIVETING MANHOLE FRAMES TO SHELLS OR DRUMS WITH TWO ROWS OF RIVETS

For two single-riveted rings: $W = \frac{l \times t_1}{4 \times t} + d$

For two double-riveted rings: $W = \frac{l \times t_1}{4 \times t} + 2d$

Where

W = least width of reinforcing ring, in.

t_1 = thickness of shell plate, in.

d = diameter of rivet when driven, in.

t = thickness of reinforcing ring—not less than thickness of the shell plate, in.

T = tensile strength of the ring, lb. per sq. in. of section

a = net section of one side of the ring or rings, sq. in.

S = shearing strength of rivet, lb. per sq. in. of section (see Par. 16)

l = length of opening in shell in direction parallel to axis of shell, in.

N = number of rivets

To find the number of rivets for a single or double reinforcing ring:

$$N = \frac{5.1 \times T \times a}{S \times d^2}$$

262 Manhole plates shall be of wrought steel or shall be steel castings.

263 The minimum width of bearing surface, for a gasket on a manhole opening shall be $\frac{1}{2}$ in. No gasket for use on a manhole or handhole of any boiler shall have a thickness greater than $\frac{1}{4}$ in.

264 A manhole shall be located in the front head, below the tubes, of a horizontal return tubular boiler 48 in. or over in diameter. Smaller boilers shall have either a manhole or a handhole below the tubes. There shall be a manhole in the upper part of the shell or head of a fire-tube boiler over 40 in. in diameter, except a vertical fire-tube boiler, or except on internally fired boilers not over 48 in. in diameter. The manhole may be placed in the head of the dome. Smaller boilers shall have either a manhole or a handhole above the tubes.

WASHOUT HOLES

265 A traction, portable or stationary boiler of the locomotive type shall have not less than six handholes, or washout plugs, located as follows: one in the rear head below the tubes; one in the front head at or about the line of the crown sheet; four in the lower part of the waterleg; also, where possible, one near the throat sheet.

266 A vertical fire-tube boiler, except the boiler of a steam fire-engine, shall have not less than seven handholes, located as follows: three in the shell at or about the line of the crown sheet; one in the shell at or about the line of the fusible plug when used; three in the shell at the lower part of the waterleg. A vertical fire-tube boiler, submerged tube type, shall have two or more handholes in the shell, in line with the upper tube sheet.

267 A vertical fire-tube boiler of a steam fire-engine shall have at least three brass washout plugs of not less than 1-in. iron pipe size, screwed into the shell and located as follows: one at or about the line of the crown sheet; two at the lower part of the waterleg.

THREADED OPENINGS

268 *Threaded Openings.* An opening in a boiler for a threaded pipe connection 1 in. in diameter or over shall have not less than the number of threads given in Table 7.

TABLE 7 MINIMUM NUMBER OF PIPE THREADS FOR CONNECTIONS TO BOILERS

Size of pipe connection, in.....	1 and 1¼	1½ and 2	2½ to 4 inclusive	4½ to 6 inclusive	7 and 8	9 and 10	12
Number of threads per in.....	11¼	11½	8	8	8	8	8
Minimum number of threads required in opening.....	4	5	7	8	10	12	13
Minimum thickness of material required to give above number of threads, in.....	0.348	0.435	0.875	1	1.25	1.5	1.625

If the thickness of the material in the boiler is not sufficient to give such number of threads, there shall be a pressed steel flange, bronze composition flange, steel-cast flange or steel plate, so as to give the required number of threads, constructed and riveted to the boiler in accordance with methods given in Par. 261. A steam main or safety valve opening may be fitted with either a steel cast, wrought-steel or bronze composition nozzle. A feed-pipe connection may be fitted with a brass or steel boiler bushing.

SAFETY VALVES

269 *Safety Valve Requirements.* Each boiler shall have two or more safety valves, except a boiler for which one safety valve 3-in. size or smaller is required by these Rules.

270 The safety valve capacity for each boiler shall be such that the safety valve or valves will discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than six per cent above the maximum allowable working pressure, or more than six per cent above the highest pressure to which any valve is set.

271 One or more safety valves on every boiler shall be set at or below the maximum allowable working pressure. The remaining

valves may be set within a range of three per cent above the maximum allowable working pressure, but the range of setting of all of the valves on a boiler shall not exceed ten per cent of the highest pressure to which any valve is set.

272 Safety valves shall be of the direct spring loaded pop type with seat and bearing surface of the disc either inclined at an angle of about 45 deg. or flat at an angle of about 90 deg. to the center line of the spindle. The vertical lift of the valve disc measured immediately after the sudden lift due to the pop may be made any amount desired up to a maximum of 0.15 in. irrespective of the size of the valve. The nominal diameter measured at the inner edge of the valve seat shall be not less than 1 in. or more than $4\frac{1}{2}$ in.

273 Each safety valve shall have plainly stamped or cast on the body:

- a* The name or identifying trade-mark of the manufacturer
- b* The nominal diameter with the words "Bevel Seat" or "Flat Seat"
- c* The steam pressure at which it is set to blow
- d* The lift of the valve disc from its seat, measured immediately after the sudden lift due to the pop
- e* The weight of steam discharged in pounds per hour at the pressure for which it is set to blow.

274 The minimum capacity of a safety valve or valves to be placed on a boiler shall be determined on the basis of 6 lb. of steam per hour per sq. ft. of boiler heating surface for water tube boilers, and 5 lb. for all other types of power boilers, and upon the relieving capacity marked on the valves by the manufacturer, provided such marked relieving capacity does not exceed that given in Table 8. In case the relieving capacity marked on the valve or valves exceeds the maximum given in Table 8, the minimum safety valve capacity shall be determined on the basis of the maximum relieving capacity given in Table 8 for the particular size of valve and working pressure for which it was constructed. The heating surface shall be computed for that side of the boiler surface exposed to the products of combustion, exclusive of the superheating surface. In computing the heating surface for this purpose only the tubes, shells, tube sheets and the projected area of headers need be considered.

**TABLE 8 DISCHARGE CAPACITIES FOR DIRECT SPRING-LOADED POP SAFETY VALVES,
WITH 45 DEG. BEVEL SEATS**

Gage Pres., Lb. per Sq. In.		Diameter, 1 In.			Diameter, 1¼ In.			Diameter, 1½ In.		
		Min.	Int.	Max.	Min.	Int.	Max.	Min.	Int.	Max.
15	Lift, in. . . .	0.02	0.04	0.05	0.03	0.04	0.05	0.03	0.05	0.06
	CH.	95,500	191,000	238,900	179,200	238,800	293,500	214,900	358,300	429,900
	Lb. hr. . . .	65	131	163	122	163	203	146	245	293
25	Lift, in. . . .	0.02	0.04	0.05	0.03	0.04	0.05	0.03	0.05	0.06
	CH.	127,700	255,400	319,300	239,500	319,300	399,100	287,400	478,900	574,700
	Lb. hr. . . .	87	174	218	164	218	272	196	326	391
50	Lift, in. . . .	0.02	0.04	0.05	0.03	0.04	0.05	0.03	0.05	0.06
	CH.	208,200	416,400	520,400	390,300	520,400	650,500	468,300	780,600	936,600
	Lb. hr. . . .	142	284	354	266	354	444	320	532	639
75	Lift, in. . . .	0.02	0.04	0.05	0.03	0.04	0.05	0.03	0.05	0.06
	CH.	288,600	577,200	721,400	541,100	721,400	901,800	649,300	1,082,000	1,299,000
	Lb. hr. . . .	197	393	492	369	492	615	443	738	880
100	Lift, in. . . .	0.02	0.04	0.05	0.03	0.04	0.05	0.03	0.05	0.06
	CH.	369,000	738,000	922,500	691,900	922,500	1,153,000	830,300	1,384,000	1,661,000
	Lb. hr. . . .	252	503	629	472	629	786	566	944	1,133
125	Lift, in. . . .	0.02	0.04	0.05	0.03	0.04	0.05	0.03	0.05	0.06
	CH.	449,400	898,900	1,124,000	842,700	1,124,000	1,404,000	1,011,000	1,685,000	2,022,000
	Lb. hr. . . .	307	613	767	575	767	957	689	1,149	1,379
150	Lift, in. . . .	0.02	0.04	0.05	0.03	0.04	0.05	0.03	0.05	0.06
	CH.	529,900	1,060,000	1,325,000	993,500	1,325,000	1,656,000	1,192,000	1,987,000	2,384,000
	Lb. hr. . . .	362	723	904	677	904	1,129	813	1,355	1,625
175	Lift, in. . . .	0.02	0.04	0.05	0.03	0.04	0.05	0.03	0.05	0.06
	CH.	610,300	1,221,000	1,526,000	1,144,000	1,526,000	1,907,000	1,373,000	2,280,000	2,746,000
	Lb. hr. . . .	416	833	1,040	780	1,040	1,301	936	1,561	1,872
200	Lift, in. . . .	0.02	0.04	0.05	0.03	0.04	0.05	0.03	0.05	0.06
	CH.	690,700	1,381,000	1,727,000	1,295,000	1,727,000	2,158,000	1,554,000	2,530,000	3,108,000
	Lb. hr. . . .	471	941	1,178	883	1,178	1,472	1,060	1,766	2,110
225	Lift, in. . . .	0.02	0.04	0.05	0.03	0.04	0.05	0.03	0.05	0.06
	CH.	771,100	1,542,000	1,928,000	1,446,000	1,928,000	2,410,000	1,735,000	2,892,000	3,470,000
	Lb. hr. . . .	526	1,052	1,315	980	1,315	1,643	1,181	1,972	2,360
250	Lift, in. . . .	0.02	0.04	0.05	0.03	0.04	0.05	0.03	0.05	0.06
	CH.	851,600	1,703,000	2,129,000	1,597,000	2,129,000	2,661,000	1,916,000	2,993,000	3,632,000
	Lb. hr. . . .	581	1,161	1,451	1,089	1,451	1,814	1,307	2,177	2,611
275	Lift, in. . . .	0.02	0.04	0.05	0.03	0.04	0.05	0.03	0.05	0.06
	CH.	932,000	1,864,000	2,330,000	1,748,000	2,330,000	2,913,000	2,097,000	3,495,000	4,194,000
	Lb. hr. . . .	635	1,271	1,589	1,192	1,589	1,986	1,430	2,383	2,860
300	Lift, in. . . .	0.02	0.04	0.05	0.03	0.04	0.05	0.03	0.05	0.06
	CH.	1,024,000	2,048,000	2,531,000	1,898,000	2,531,000	3,164,000	2,278,000	3,797,000	4,556,000
	Lb. hr. . . .	698	1,397	1,746	1,294	1,726	2,157	1,553	2,589	3,107

The Discharge capacity of a Flat Seat Valve of a given diameter with a given lift may be obtained by multiplying the discharge capacity given in the Table for a 45 deg. bevel seat valve of same diameter and same lift, by 1.4.

TABLE 8 (CONTINUED) DISCHARGE CAPACITIES FOR DIRECT SPRING-LOADED POP SAFETY VALVES, WITH 45 DEG. BEVEL SEATS

Gage Pres., Lb. per Sq. In.		Diameter, 2 In.			Diameter, 2½ In.			Diameter, 3 In.		
		Min.	Int.	Max.	Min.	Int.	Max.	Min.	Int.	Max.
15	Lift, in. . . .	0.04	0.06	0.07	0.04	0.06	0.08	0.05	0.08	0.10
	CH.	382,200	573,300	668,900	477,700	716,600	955,500	716,600	1,147,000	1,433,000
	Lb. hr.	261	391	450	326	488	651	489	782	977
25	Lift, in. . . .	0.04	0.06	0.07	0.04	0.06	0.08	0.05	0.08	0.10
	CH.	510,900	766,300	894,000	638,500	957,900	1,277,000	957,900	1,533,000	1,916,000
	Lb. hr.	349	523	610	435	653	871	653	1046	1307
50	Lift, in. . . .	0.04	0.06	0.07	0.04	0.06	0.08	0.05	0.08	0.10
	CH.	832,600	1,249,000	1,457,000	1,041,000	1,561,000	2,081,000	1,561,000	2,498,000	3,122,000
	Lb. hr.	568	851	994	710	1064	1419	1064	1703	2129
75	Lift, in. . . .	0.04	0.06	0.07	0.04	0.06	0.08	0.05	0.08	0.10
	CH.	1,154,000	1,731,000	2,020,000	1,443,000	2,164,000	2,886,000	2,164,000	3,463,000	4,329,000
	Lb. hr.	787	1181	1377	984	1475	1968	1475	2361	2951
100	Lift, in. . . .	0.04	0.06	0.07	0.04	0.06	0.08	0.05	0.08	0.10
	CH.	1,476,000	2,214,000	2,583,000	1,845,000	2,768,000	3,690,000	2,768,000	4,428,000	5,535,000
	Lb. hr.	1007	1510	1761	1258	1887	2516	1887	3019	3774
125	Lift, in. . . .	0.04	0.06	0.07	0.04	0.06	0.08	0.05	0.08	0.10
	CH.	1,795,000	2,693,000	3,146,000	2,247,000	3,371,000	4,494,000	3,371,000	5,393,000	6,741,000
	Lb. hr.	1224	1836	2145	1532	2290	3004	2299	3677	4596
150	Lift, in. . . .	0.04	0.06	0.07	0.04	0.06	0.08	0.05	0.08	0.10
	CH.	2,109,000	3,179,000	3,709,000	2,649,000	3,974,000	5,299,000	3,974,000	6,358,000	7,948,000
	Lb. hr.	1438	2158	2529	1806	2710	3613	2710	4335	5419
175	Lift, in. . . .	0.04	0.06	0.07	0.04	0.06	0.08	0.05	0.08	0.10
	CH.	2,441,000	3,662,000	4,272,000	3,051,000	4,577,000	6,103,000	4,577,000	7,323,000	9,154,000
	Lb. hr.	1664	2497	2913	2081	3121	4161	3121	4993	6242
200	Lift, in. . . .	0.04	0.06	0.07	0.04	0.06	0.08	0.05	0.08	0.10
	CH.	2,763,000	4,144,000	4,835,000	3,454,000	5,180,000	6,907,000	5,180,000	8,289,000	10,361,000
	Lb. hr.	1884	2826	3296	2354	3532	4709	3532	5651	7064
225	Lift, in. . . .	0.04	0.06	0.07	0.04	0.06	0.08	0.05	0.08	0.10
	CH.	3,085,000	4,626,000	5,398,000	3,856,000	5,784,000	7,711,000	5,784,000	9,254,000	11,567,000
	Lb. hr.	2104	3154	3680	2629	3944	5258	3944	6310	7890
250	Lift, in. . . .	0.04	0.06	0.07	0.04	0.06	0.08	0.05	0.08	0.10
	CH.	3,406,000	5,109,000	5,961,000	4,258,000	6,387,000	8,516,000	6,387,000	10,219,000	12,774,000
	Lb. hr.	2322	3484	4064	2903	4355	5807	4355	6968	8708
275	Lift, in. . . .	0.04	0.06	0.07	0.04	0.06	0.08	0.05	0.08	0.10
	CH.	3,728,000	5,592,000	6,524,000	4,660,000	6,990,000	9,320,000	6,990,000	11,180,000	13,980,000
	Lb. hr.	2542	3813	4448	3177	4766	6355	4766	7620	9533
300	Lift, in. . . .	0.04	0.06	0.07	0.04	0.06	0.08	0.05	0.08	0.10
	CH.	4,050,000	6,075,000	7,087,000	5,062,000	7,593,000	10,124,000	7,593,000	12,149,000	15,186,000
	Lb. hr.	2762	4143	4832	3452	5177	6903	5177	8280	10,358

The Discharge capacity of a Flat Seat Valve of a given diameter with a given lift may be obtained by multiplying the discharge capacity given in the Table for a 45 deg. bevel seat valve of same diameter and same lift, by 1.4.

This table is concluded on the following page.

TABLE 8 (CONCLUDED) DISCHARGE CAPACITIES FOR DIRECT SPRING-LOADED POP SAFETY VALVES, WITH 45 DEG. BEVEL SEATS

Gage Pres., Lb. per Sq. In.		Diameter, 3½ In.			Diameter, 4 In.			Diameter, 4½ In.		
		Min.	Int.	Max.	Min.	Int.	Max.	Min.	Int.	Max.
15	Lift, in. . . .	0.06	0.09	0.11	0.07	0.10	0.12	0.08	0.11	0.13
	CH.	1,003,000	1,505,000	1,839,000	1,338,000	1,911,000	2,293,000	1,720,000	2,365,000	2,795,000
	Lb. hr. . . .	684	1026	1254	912	1303	1564	1173	1613	1906
25	Lift, in. . . .	0.06	0.09	0.11	0.07	0.10	0.12	0.08	0.11	0.13
	CH.	1,341,000	2,012,000	2,459,000	1,788,000	2,554,000	3,065,000	2,299,000	3,161,000	3,736,000
	Lb. hr. . . .	914	1372	1676	1219	1742	2090	1568	2156	2547
50	Lift, in. . . .	0.06	0.09	0.11	0.07	0.10	0.12	0.08	0.11	0.13
	CH.	2,186,000	3,278,000	4,007,000	2,914,000	4,163,000	4,996,000	3,747,000	5,152,000	6,088,000
	Lb. hr. . . .	1490	2235	2732	1987	2839	3406	2555	3513	4151
75	Lift, in. . . .	0.06	0.09	0.11	0.07	0.10	0.12	0.08	0.11	0.13
	CH.	3,030,000	4,545,000	5,555,000	4,040,000	5,772,000	6,926,000	5,194,000	7,142,000	8,441,000
	Lb. hr. . . .	2066	3099	3788	2754	3935	4722	3542	4870	5756
100	Lift, in. . . .	0.06	0.09	0.11	0.07	0.10	0.12	0.08	0.11	0.13
	CH.	3,875,000	5,812,000	7,103,000	5,166,000	7,380,000	8,856,000	6,642,000	9,133,000	10,793,000
	Lb. hr. . . .	2642	3963	4843	3522	5032	6038	4529	6227	7358
125	Lift, in. . . .	0.06	0.09	0.11	0.07	0.10	0.12	0.08	0.11	0.13
	CH.	4,719,000	7,079,000	8,652,000	6,292,000	8,988,000	10,786,000	8,089,000	11,123,000	13,146,000
	Lb. hr. . . .	3218	4826	5899	4290	6128	7354	5516	7583	8963
150	Lift, in. . . .	0.06	0.09	0.11	0.07	0.10	0.12	0.08	0.11	0.13
	CH.	5,564,000	8,345,000	10,199,000	7,418,000	10,597,000	12,717,000	9,537,000	13,114,000	15,498,000
	Lb. hr. . . .	3794	5690	6954	5058	7226	8670	6503	8940	10566
175	Lift, in. . . .	0.06	0.09	0.11	0.07	0.10	0.12	0.08	0.11	0.13
	CH.	6,408,000	9,612,000	11,748,000	8,544,000	12,206,000	14,647,000	10,985,000	15,105,000	17,851,000
	Lb. hr. . . .	4369	6553	8010	5824	8320	9984	7490	10298	12173
200	Lift, in. . . .	0.06	0.09	0.11	0.07	0.10	0.12	0.08	0.11	0.13
	CH.	7,253,000	10,879,000	13,296,000	9,670,000	13,814,000	16,580,000	12,433,000	17,095,000	20,204,000
	Lb. hr. . . .	4946	7418	9068	6593	9420	11305	8475	11655	13773
225	Lift, in. . . .	0.06	0.09	0.11	0.07	0.10	0.12	0.08	0.11	0.13
	CH.	8,097,000	12,146,000	14,845,000	10,796,000	15,423,000	18,507,000	13,881,000	19,086,000	22,556,000
	Lb. hr. . . .	5521	8280	10120	7361	10514	12616	9465	13013	15383
250	Lift, in. . . .	0.06	0.09	0.11	0.07	0.10	0.12	0.08	0.11	0.13
	CH.	8,942,000	13,412,000	16,393,000	11,922,000	17,031,000	20,438,000	15,328,000	21,076,000	24,908,000
	Lb. hr. . . .	6097	9143	11175	8130	11614	13938	10448	14366	16980
275	Lift, in. . . .	0.06	0.09	0.11	0.07	0.10	0.12	0.08	0.11	0.13
	CH.	9,786,000	14,679,000	17,941,000	13,048,000	18,640,000	22,368,000	16,776,000	23,067,000	27,261,000
	Lb. hr. . . .	6672	10005	12233	8895	12707	15248	11438	15728	18585
300	Lift, in. . . .	0.06	0.09	0.11	0.07	0.10	0.12	0.08	0.11	0.13
	CH.	10,630,000	15,946,000	19,489,000	14,174,000	20,249,000	24,298,000	18,224,000	25,058,000	29,614,000
	Lb. hr. . . .	7248	10875	13290	9668	13807	16568	12428	17088	20195

The Discharge capacity of a Flat Seat Valve of a given diameter with a given lift may be obtained by multiplying the discharge capacity given in the Table for a 45 deg. bevel seat valve of same diameter and same lift, by 1.4.

275 Safety valve capacity may be checked in any one of three different ways, and if found sufficient, additional capacity need not be provided:

- a* By making an accumulation test, by shutting off all other steam discharge outlets from the boiler and forcing the fires to the maximum. The safety valve equipment shall be sufficient to prevent an excess pressure beyond six per cent as specified in Par. 270.
- b* By measuring the maximum amount of fuel that can be burned and computing the corresponding evaporative capacity upon the basis of the heating value of the fuel. See Appendix, Pars. 421 to 427.
- c* By determining the maximum evaporative capacity by measuring the feed water. The sum of the safety valve capacities marked on the valves, shall be equal to or greater than the maximum evaporative capacity of the boiler.

276 When two or more safety valves are used on a boiler, they may be either separate or twin valves made by mounting individual valves on Y-bases, or duplex, triplex or multiplex valves having two or more valves in the same body casing.

277 The safety valve or valves shall be connected to the boiler independent of any other steam connection, and attached as close as possible to the boiler, without any unnecessary intervening pipe or fitting. Every safety valve shall be connected so as to stand in an upright position, with spindle vertical, when possible.

278 Each safety valve shall have full sized direct connection to the boiler. No valve of any description shall be placed between the safety valve and the boiler, nor on the discharge pipe between the safety valve and the atmosphere. When a discharge pipe is used, it shall be not less than the full size of the valve, and shall be fitted with an open drain to prevent water from lodging in the upper part of the safety valve or in the pipe.

279 If a muffler is used on a safety valve it shall have sufficient outlet area to prevent back pressure from interfering with the proper operation and discharge capacity of the valve. The muffler plates or other devices shall be so constructed as to avoid any possibility of restriction of the steam passages due to deposit. When an elbow is placed on a safety valve discharge pipe, it shall be located close to the safety valve outlet or the pipe shall be securely anchored and supported. All safety valve discharges shall be so located or piped as to be carried

clear from running boards or working platforms used in controlling the main stop valves of boilers or steam headers.

280 When a boiler is fitted with two or more safety valves on one connection, this connection to the boiler shall have a cross-sectional area not less than the combined area of all of the safety valves with which it connects.

281 Safety valves shall operate without chattering and shall be set and adjusted as follows: To close after blowing down not more than 4 lb. on boilers carrying an allowed pressure less than 100 lb. per sq. in. gage. To close after blowing down not more than 6 lb. on boilers carrying pressures between 100 and 200 lb. per sq. in. gage inclusive. To close after blowing down not more than 8 lb. on boilers carrying over 200 lb. per sq. in. gage.

282 Each safety valve used on a boiler shall have a substantial lifting device, and shall have the spindle so attached that the valve disc can be lifted from its seat a distance not less than one-tenth of the nominal diameter of the valve, when there is no pressure on the boiler.

283 The seats and discs of safety valves shall be of non-ferrous material.

284 Springs used in safety valves shall not show a permanent set exceeding $1/32$ in. ten minutes after being released from a cold compression test closing the spring solid.

285 The spring in a safety valve shall not be used for any pressure more than 10 per cent above or below that for which it was designed.

286 A safety valve over 3-in. size, used for pressures greater than 15 lb. per sq. in. gage, shall have a flanged inlet connection. The dimensions of the flanges shall conform to the American standard given in Tables 15 and 16 of the Appendix.

287 When the letters *A S M E Std* are plainly stamped or cast on the valve body this shall be a guarantee by the manufacturer that the valve conforms with the details of construction herein specified.

288 Every superheater shall have one or more safety valves near the outlet. The discharge capacity of the safety valve or valves on an attached superheater may be included in determining the number and sizes of the safety valves for the boiler, provided there are no intervening valves between the superheater safety valve and the boiler.

289 Every safety valve used on a superheater, discharging superheated steam, shall have a steel body with a flanged inlet connection,

and shall have the seat and disc of nickel composition or equivalent material, and the spring fully exposed outside of the valve casing so that it shall be protected from contact with the escaping steam.

290 Every boiler shall have proper outlet connections for the required safety valve or valves, independent of any other steam outlet connection or of any internal pipe in the steam space of the boiler, the area of opening to be at least equal to the aggregate area of all of the safety valves to be attached thereto.

WATER AND STEAM GAGES

291 *Water Glasses and Gage Cocks.* Each boiler shall have at least one water glass, the lowest visible part of which shall be not less than 2 in. above the lowest permissible water level.

292 No water glass connection shall be fitted with an automatic shut-off valve.

293 When shut-offs are used on the connections to a water column, they shall be either outside screw and yoke type gate valves or stop cocks with levers permanently fastened thereto, and such valves or cocks shall be locked or sealed *open*.

294 Each boiler shall have three or more gage cocks, located within the range of the visible length of the water glass, except when such boiler has two water glasses with independent connections to the boiler and located on the same horizontal line and not less than 2 ft. apart.

295 No outlet connections, except for damper regulator, feed-water regulator, drains or steam gages, shall be placed on the pipes connecting a water column to a boiler.

296 *Steam Gages.* Each boiler shall have a steam gage connected to the steam space or to the water column or its steam connection. The steam gage shall be connected to a syphon or equivalent device of sufficient capacity to keep the gage tube filled with water and so arranged that the gage cannot be shut off from the boiler except by a cock placed near the gage and provided with a tee or lever handle arranged to be parallel to the pipe in which it is located when the cock is open. Connections to gages shall be of brass, copper or bronze composition.

297 The dial of the steam gage shall be graduated to not less than $1\frac{1}{2}$ times the maximum allowable working pressure on the boiler.

298 Each boiler shall be provided with a $\frac{1}{4}$ -in. pipe size valved

connection for attaching a test gage when the boiler is in service, so that the accuracy of the boiler steam gage can be ascertained.

FITTINGS AND APPLIANCES

299 *Nozzles and Fittings.* All fittings shall conform to the American Standards given in Tables 15 or 16 of the Appendix. Where the maximum allowable working pressure is less than 125 lb. per sq. in., Table 15 shall be used and where higher, Table 16.

300 The minimum number of threads that a pipe or fitting shall screw into a tapped hole shall correspond to the numerical values given for number of threads in Table 7.

301 *Stop Valves.* Each steam discharge outlet over 2 in. in diameter, except safety valve and superheater connections, shall be fitted with a stop valve or valves of the outside screw and yoke type, located as near the boiler as practicable.

302 The main stop valves of boilers shall be extra heavy when the maximum allowable working pressure exceeds 125 lb. per sq. in. The fittings between the boiler and such valve or valves shall be extra heavy, as specified in Table 16 of the Appendix.

303 When two or more boilers are connected to a common steam main, two stop valves, with an ample free blow drain between them, shall be placed in the steam connection between each boiler and the steam main. The discharge of this drain valve must be visible to the operator while manipulating the valve. The stop valves shall consist preferably of one automatic non-return valve (set next the boiler) and a second valve of the outside screw and yoke type; or, two valves of the outside screw and yoke type may be used.

304 When a stop valve is so located that water can accumulate, ample drains shall be provided.

305 *Steam Mains.* Provisions shall be made for the expansion and contraction of steam mains connected to boilers, by providing substantial anchorage at suitable points, so that there shall be no undue strain transmitted to the boiler. Steam reservoirs shall be used on steam mains when heavy pulsations of the steam currents cause vibration of the boiler shell plates.

306 Each superheater shall be fitted with a drain.

307 *Blow-off Piping.* The size of a surface blow-off pipe shall not exceed 1½ in., and it shall be carried through the shell or head with a brass or steel boiler bushing.

308 Each boiler shall have a bottom blow-off pipe, fitted with a valve or cock, in direct connection with the lowest water space practicable; the minimum size of pipe and fittings shall be 1 in. and the maximum size shall be $2\frac{1}{2}$ in. Globe valves shall not be used on such connections.

309 A bottom blow-off cock shall have the plug held in place by a guard or gland. The end of the plug shall be distinctly marked in line with the passage.

310 The blow-off pipe or pipes shall be extra heavy from boiler to valve or valves, and shall run full size without reducers or bushings. All fittings between the boiler and valves shall be of steel.

311 When the maximum allowable working pressure exceeds 125 lb. per sq. in., the bottom blow-off pipe shall have two valves, or a valve and a cock, and such valves, or valve and cock, shall be extra heavy, except that on a boiler having multiple blow-off pipes, a single master valve may be placed on the common blow-off pipe from the boiler, in which case only one valve on each individual blow-off is required.

312 A bottom blow-off pipe when exposed to direct furnace heat shall be protected by fire-brick, a substantial cast-iron removable sleeve or a covering of non-conducting material.

313 An opening in the boiler setting for a blow-off pipe shall be arranged to provide for free expansion and contraction.

314 *Feed Piping.* The feed pipe of a boiler shall have an open end or ends. Wherever globe valves are used on feed piping, the inlet shall be under the disc of the valve.

315 The feedwater shall discharge at about three-fifths the length of a horizontal return tubular boiler from the front head (except a horizontal return tubular boiler equipped with an auxiliary feedwater heating and circulating device), above the central rows of tubes, when the diameter of the boiler exceeds 36 in. The feed pipe shall be carried through the head or shell near the front end with a brass or steel boiler bushing, and securely fastened inside the shell above the tubes.

316 Feedwater shall not discharge in a boiler close to riveted joints in the shell or to furnace sheets.

317 The feed pipe shall be provided with a check valve near the boiler and a valve or cock between the check valve and the boiler, and when two or more boilers are fed from a common source, there shall also be a globe valve on the branch to each boiler, between the check valve and the source of supply.

318 When a pump, inspirator or injector is required to supply feedwater to a boiler plant of over 50 h. p., more than one such appliance shall be provided.

319 *Lamphrey Fronts.* Each boiler fitted with a Lamphrey boiler furnace mouth protector, or similar appliance, having valves on the pipes connecting them to the boiler, shall have these valves locked or sealed *open*. Such valves when used, shall be of the straight-way type.

320 *Water Column Pipes.* The minimum size of pipes connecting the water column to a boiler shall be 1 in. Water-glass fittings or gage cocks may be connected direct to the boiler.

321 The water connections to the water column of a boiler shall be of brass and shall be provided with a cross to facilitate cleaning. Either the water column or this connection shall be fitted with a drain cock or drain valve with a suitable connection to the ashpit, or other safe point of waste. The water column blow-off pipe shall be at least $\frac{3}{4}$ in.

322 The steam connection to the water column of a horizontal return tubular boiler shall be taken from the top of the shell or the upper part of the head; the water connection shall be taken from a point not less than 6 in. below the center line of the shell.

SETTING

323 *Methods of Support.* A horizontal return tubular boiler over 78-in. in diameter shall be supported from steel lugs by the outside suspension type of setting, independent of the boiler side walls. The lugs shall be so designed that the load is properly distributed between the rivets attaching them to the shell and so that not more than two of these rivets come in the same longitudinal line on each lug. The distance girthwise of the boiler from the centers of the bottom rivets to the centers of the top rivets attaching the lugs shall be not less than 12 in. The other rivets used shall be spaced evenly between these points. If more than four lugs are used they shall be set in four pairs.

324 A horizontal return tubular boiler over 54 in., and up to and including 78 in. in diameter, shall be supported by the outside suspension type of setting, or at four points by not less than eight steel or cast-iron brackets set in pairs. A horizontal return tubular boiler up to and including 54 in. in diameter shall be supported by the outside suspension type of setting, or by not less than two steel or cast-iron brackets on each side.

325 Lugs or brackets, when used to support boilers, shall be properly fitted to the surfaces to which they are attached. The shearing stress on the rivets used for attaching the lugs or brackets shall not exceed 8 per cent of the strength given in Par. 16.

326 Wet-bottom stationary boilers shall have a space of not less than 12 in. between the bottom of the boiler and the floor line, with access for inspection.

327 *Access and Firing Doors.* The minimum size of an access door to be placed in a boiler setting shall be 12×16 in. or equivalent area, 11 in. to be the least dimension in any case.

328 A water tube boiler which is fired by hand shall have firing door or doors of the inward opening type unless such doors are provided with substantial latching devices to prevent them from being blown open by pressure on the furnace side.

HYDROSTATIC TESTS

329 *Hydrostatic Pressure Tests.* After a boiler has been completed, it shall be subjected to a hydrostatic test of one and one-half times the maximum allowable working pressure. The pressure shall be under proper control so that in no case shall the required test pressure be exceeded by more than 6 per cent.

330 During a hydrostatic test, the safety valve or valves shall be removed or each valve disc shall be held to its seat by means of a testing clamp and not by screwing down the compression screw upon the spring.

STAMPING

331 *Stamping of Boilers.* In laying out shell plates, furnace sheets and heads in the boiler shop, care shall be taken to leave at least one of the stamps, specified in Par. 36 of these Rules, so located as to be plainly visible when the boiler is completed; except that the tube sheets of a vertical fire-tube boiler and butt straps shall have at least a portion of such stamps visible sufficient for identification when the boiler is completed.

332 Each boiler shall conform in every detail to these Rules, and shall be distinctly stamped with the symbol as shown in Fig. 19, denoting that the boiler was constructed in accordance therewith. Each boiler shall also be stamped by the builder with a serial number and

with the builder's name either in full or abbreviated, as indicated in Fig. 20. The height of the letters and figures used in stamping shall be not less than $\frac{1}{4}$ in. and this stamp shall be placed directly below or alongside The American Society of Mechanical Engineers' stamp.



FIG. 19 OFFICIAL SYMBOL FOR STAMP
TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS UNIFORM STANDARD

(Name of State)	.....STD
(Number of Boiler)	1
(Name of Builder)	.....

FIG. 20 FORM OF STAMP PROPOSED
FOR THE BOILER MANUFACTURER

333 *Location of Stamps.* The location of stamps shall be as follows:

- a* On horizontal return tubular boilers—on the front head, above the central rows of tubes.
- b* On horizontal flue boilers—on the front head, above the flues.
- c* On traction, portable or stationary boilers of the locomotive type or Star water-tube boilers—on the furnace end, above the handhole.
- d* On vertical fire tube and vertical submerged tube boilers—on the shell above the fire door.
- e* On water-tube boilers, Babcock & Wilcox, Stirling, Heine and Robb-Mumford standard types—on a head above the manhole opening, preferably on the flanging of the manhole opening.
- f* On vertical boilers, Climax or Hazleton type—on the top head.
- g* On Cahall or Wickes vertical water tube boilers—on the upper drum, above the manhole opening.
- h* On Scotch marine boilers—on the front head, above the center or right-hand furnace.
- i* On Economic boilers—on the front head, above the central row of tubes.
- j* For other types and new designs—in a conspicuous location.

334 The American Society of Mechanical Engineers' standard stamp and the boiler builder's stamps shall not be covered by insulating or other material.

NEW INSTALLATIONS

PART I — SECTION II

BOILERS USED EXCLUSIVELY FOR LOW PRESSURE STEAM AND HOT WATER HEATING AND HOT WATER SUPPLY

(This does not apply to economizers or feed water heaters.)

BOILER MATERIALS

335 The Rules for power boilers shall apply:

- a To all steel plate *hot-water* boilers over 60 in. in diameter.
- b To all steel plate *hot-water* boilers where the grate area exceeds 10 sq. ft. and the maximum allowable working pressure exceeds 50 lbs. per sq. in.
- c Under other conditions, the following rules (Pars. 336 and 337) shall apply.

336 Specifications are given in these rules, Pars. 23 to 178, for the important materials used in the construction of boilers, and where given, the materials shall conform thereto.

337 Flange steel may be used entirely for the construction of steam heating boilers covered in this section, but in no case shall steel of less than $\frac{1}{4}$ in. thickness, nor tube sheets or heads of less than $\frac{5}{16}$ in. in thickness be used.

MAXIMUM ALLOWABLE WORKING PRESSURE

338 The maximum allowable working pressure shall not exceed 15 lbs. per sq. in. on a boiler built under these rules to be used exclusively for low pressure steam heating.

339 A boiler to be used exclusively for low pressure steam heating may be constructed of cast-iron with connecting nipples of cast-iron, malleable iron, wrought-iron or steel and bolts of wrought-iron or steel, or wholly of steel or wrought-iron, or of steel and partially cast-iron, or of steel or wrought iron with cast-iron mud rings, door frames and manhole flanges. Threaded cast-iron nipples of less than four inches diameter shall not be used.

340 All steel plate, *hot-water* and *steam-heating* boilers shall have a factor of safety not less than 5.

BOILER JOINTS

341 Longitudinal lap joints will be allowed on boilers to be used exclusively for low pressure *steam* heating, when the maximum allowable working pressure does not exceed 15 lbs. per sq. in., and the diameter of the boiler shell does not exceed 60 in.

342 The longitudinal joints of a horizontal return tubular boiler, if of the lap type, shall be not over 12 ft. in length.

343 In a *hot-water* boiler to be used exclusively for heating buildings or hot-water supply when the diameter does not exceed 60 in. and the grate area does not exceed 10 sq. ft., longitudinal lap joints will be allowed.

When the grate area exceeds 10 sq. ft. and the diameter of the boiler does not exceed 60 in., longitudinal lap joints will be allowed providing the maximum allowable working pressure does not exceed 50 lbs. per sq. in.

344 *Protection of Joints.* When a boiler is built wholly or partially of steel and is used exclusively for low pressure *steam* heating, or when a *hot-water* boiler is used exclusively for heating buildings or for hot-water supply, it shall not be necessary to water jacket the rivets in the fire-box where one end of each rivet is exposed to the fire or direct radiant heat from the fire, provided any one of the following conditions is fulfilled:

- a Where the ends of the rivets away from the fire are protected by means of natural drafts of cold air induced in the regular operation of the boiler;
- b Where the ends of the rivets away from the fire are in the open air;
- c Where the rivets are protected by the usual charges of fresh fuel, which is not burned in contact with the rivets.

WASHOUT HOLES

345 A boiler used for hot-water supply shall have washout holes or other provision made for the removal of any sediment that may accumulate therein.

BOILER OPENINGS

346 *Flanged Connections.* Openings in boilers having flanged connections shall have the flanges conform to the American Standard given in Tables 15 or 16 of the Appendix, for the corresponding pipe size, and shall have the corresponding drilling for bolts or studs.

SAFETY VALVES

347 *Outlet Connections for Safety and Water Relief Valves.* Every boiler shall have proper outlet connections for the required

safety, or water relief valve or valves, independent of any other connection outside of the boiler or any internal pipe in the boiler, the area of the opening to be at least equal to the aggregate area of all of the safety valves with which it connects. A screwed connection may be used for attaching a safety valve to a heating boiler. This rule applies to all sizes of safety valves.

348 *Safety Valves.* Each *steam* boiler shall be provided with one or more safety valves of the spring-pop type which cannot be adjusted to a higher pressure than 15 lbs. per sq. in.

349 *Water-Relief Valves.* Each *hot-water* boiler shall be provided with one or more water relief valves with open discharges having outlets in plain sight.

350 A boiler used for heating buildings by hot water, or for hot water supply, shall be provided with a water relief valve or valves, which cannot be adjusted for a pressure in excess of the maximum pressure allowed on the boiler. All water relief valves must be fitted with a device for lifting the disc of the valve from its seat so that the working condition can be ascertained.

351 No water relief valve shall be smaller than one inch. Water relief valves to be of the following sizes:

When the grate area does not exceed 8 sq. ft., a water relief valve not less than 1 in. size shall be used.

When the grate area exceeds 8 square feet, but does not exceed 13 square feet, a water relief valve not less than $1\frac{1}{4}$ -in. size shall be used.

When the grate area exceeds 13 sq. ft., but does not exceed 18 sq. ft., a water relief valve not less than $1\frac{1}{2}$ -in. size shall be used.

When the grate area exceeds 18 sq. ft., a water relief valve not less than 2-in. size shall be used.

352 When two or more safety or water relief valves are used on a boiler, they may be single or twin valves.

353 Safety or water relief valves shall be connected to boilers independent of other connections and be attached directly or as close as possible to the boiler, without any intervening pipe or fittings, except the Y-base forming a part of the twin valve or the shortest possible connection. A safety or water relief valve shall not be connected to an internal pipe in the boiler. Safety valves shall be connected so as to stand upright, with the spindle vertical, when possible.

354 No shut-off of any description shall be placed between the safety or water relief valve and boilers, nor on discharge pipes between them and the atmosphere.

355 When a discharge pipe is used, its area shall be not less than the area of the valve or aggregate area of the valves with which it

connects, and the discharge pipe shall be fitted with an open drain to prevent water from lodging in the upper part of the valve or in the pipe. When an elbow is placed on a safety or water relief valve discharge pipe, it shall be located close to the valve outlet or the pipe shall be securely anchored and supported. The safety or water relief valves shall be located as provided in Par. 353, and the discharge outlet so arranged that there will be no danger from scalding.

356 Each safety valve used on a *steam* heating boiler shall have a substantial lifting device which shall be so connected to the disc that the latter can be lifted from its seat a distance of not less than one-tenth of the nominal diameter of the seat when there is no pressure on the boiler.

TABLE 9. ALLOWABLE SIZES OF SAFETY VALVES FOR HEATING BOILERS

Water Evaporated per Square Foot of Grate Surface per Hour, Lbs.		75	100	160	160	200	240
Maximum Allowable Working Pressure, Lbs. per Square Inch		Zero to 25 Lbs.	Over 25 to 50 Lbs.	Over 50 to 100 Lbs.	Over 100 to 150 Lbs.	Over 150 to 200 Lbs.	Over 200 Lbs.
Diameter of Valve, Inches	Area of Valve, Square Inches	Area of Grate, Square Feet					
1	0.7854	2.00	2.50	2.75	3.25	3.5	3.75
1½	1.2272	3.25	4.00	4.25	5.00	5.5	5.75
1½	1.7671	4.50	5.50	6.00	7.25	8.0	8.50
2	3.1416	8.00	9.75	10.75	13.00	14.0	15.00
2½	4.9087	12.50	15.00	16.50	20.00	22.0	23.00
3	7.0686	17.75	21.50	24.00	29.00	31.5	33.25
3½	9.6211	24.00	29.50	32.50	39.50	43.0	45.25
4	12.5660	31.50	38.25	42.50	51.50	56.0	59.00
4½	15.9040	40.00	48.50	53.50	65.00	71.0	74.25

357 Every safety valve or water relief valve shall have plainly stamped on the body or cast thereon the manufacturer's name or trade mark and the pressure at which it is set to blow. The seats and discs of safety or water relief valves shall be made of non-ferrous material.

358 The minimum size of a safety valve for a steam boiler shall be one inch, and the maximum size shall be 4½ inches. The size of safety valve required for a steam boiler shall be governed by the grate area of the boiler as shown in Table number 9 and the pressure allowed.

When the conditions exceed those on which Table 9 is based, the following formula for bevel and flat seated valves shall be used:

$$A = \frac{W 70}{P} \times 11$$

in which

A = area of direct spring-loaded safety valve per square foot of grate surface, sq. in.

W = weight of water evaporated per square foot of grate surface per second, lb.

P = pressure (absolute) at which the safety valve is set to blow, lbs. per sq. in.

359 *Double Grate Down Draft Boilers.* In determining the number and size of safety valves the grate area shall equal the area of the upper or water grate.

360 *Boilers Fired with Oil or Gas.* In determining the number and size of safety or water relief valve or valves for a boiler using gas or liquid fuel, 15 sq. ft. of heating surface shall be equivalent to one square foot of grate area. If the size of grate for use of coal is evident from the boiler design, such size may be the basis for the determination of the safety valve capacity.

STEAM AND WATER GAGES

361 *Steam Gages.* Each *steam* boiler shall have a steam gage connected to the steam space or to the water column or its steam connection. The steam gage shall be connected to a syphon or equivalent device of sufficient capacity to keep the gage tube filled with water and so arranged that the gage cannot be shut off from the boiler except by a cock placed near the gage and provided with a tee or lever handle arranged to be parallel to the pipe in which it is located when the cock is open. Connections to gages shall be of brass, copper or bronze composition. The dial of a steam gage for a *steam* heating boiler shall be graduated to not less than 30 lbs.

362 *Pressure or Altitude Gages.* Each *hot-water* boiler shall have a gage connected in such a manner that it cannot be shut off from the boiler except by a cock with tee or lever handle, placed on the pipe near the gage. The handle of the cock shall be parallel to the pipe in which it is located when the cock is open. Connections to gages shall be made of brass, copper or bronze composition. The dial of the pressure or altitude gage shall be graduated to not less than $1\frac{1}{2}$ times the maximum allowable working pressure.

363 *Thermometers.* Each *hot-water* boiler shall have a thermometer so located and connected that it shall be easily readable

when observing the water pressure or altitude. The thermometer shall be so located that it shall at all times indicate the temperature in deg. Fahr., of the water in the boiler.

FITTINGS AND APPLIANCES

364 *Bottom Blow-Off Pipes.* Each boiler shall have a blow-off pipe, fitted with a valve or cock, in direct connection with the lowest water space practicable.

365 *Damper Regulators.* When a pressure damper regulator is used, the boiler pressure pipe shall be connected to the steam space of the boiler.

366 *Water Glasses.* Each *steam* boiler shall have one or more water glasses.

367 *Gage Cocks.* Each *steam* boiler shall have two or more gage cocks located within the range of the visible length of the water glass.

368 *Water Column Pipes.* The minimum size of pipes connecting the water column of a boiler shall be 1 in. Water-glass fittings or gage cocks may be connected direct to the boiler. The steam connection to the water column of a horizontal return tubular boiler shall be taken from the top of shell or the upper part of the head; the water connection shall be taken from a point not less than 6 in. below the center line of the shell. No connections, except for damper regulator, oil burner regulator, feed water regulator, drains or steam gages, shall be placed on the pipes connecting a water column to a boiler.

METHODS OF SETTING

369 Wet-bottom steel plate boilers shall have a space of not less than 12 in. between the bottom of the boiler and the floor line with access for inspection.

370 *Access Doors.* The minimum size of access door used in boiler settings shall be 12 x 16 in. or equivalent area, the least dimension being 11 in.

371 The longitudinal joints of a horizontal return tubular boiler shall be located above the fire-line.

HYDROSTATIC TESTS

372 A shop test of 60 lbs. per sq. in. hydrostatic pressure shall be applied to steel or cast-iron boilers or to the sections of cast-iron boilers which are used exclusively for low pressure *steam* heating.

373 *Hot-water* boilers for a maximum allowable working pressure not exceeding 30 lbs. per sq. in. used exclusively for heating buildings

or for hot-water supply, when constructed of cast-iron, including the nipples, or of cast-iron excepting the connecting nipples and bolts, shall be subjected to a shop test of 60 lbs. per sq. in. hydrostatic pressure applied to the boiler or the sections thereof.

374 A maximum allowable working pressure in excess of 30 lbs. per sq. in. will be allowed on a *hot-water* boiler constructed of cast-iron, including the nipples, or of cast-iron excepting the connecting nipples and bolts, used exclusively for heating buildings or for hot-water supply, provided such boilers or their sections have been subjected to a shop hydrostatic test of two and one-half times the actual working pressure.

375 Individual shop inspection shall be required only for boilers which come under the rules for power boilers.

STAMPING

376 Each plate of a completed boiler shall show a sufficient portion of the plate maker's stamp for identification.

377 *Name.* All boilers referred to in this section shall be plainly and permanently marked with the manufacturer's name and the maximum allowable working pressure.

EXISTING INSTALLATIONS

PART II

MAXIMUM ALLOWABLE WORKING PRESSURE

378 The maximum allowable working pressure on the shell of a boiler or drum shall be determined by the strength of the weakest course, computed from the thickness of the plate, the tensile strength of the plate, the efficiency of the longitudinal joint, the inside diameter of the course and the factor of safety allowed by these rules.

$$\frac{TS \times t \times E}{R \times FS} = \text{maximum allowable working pressure, lb. per sq. in. where}$$

TS = ultimate tensile strength of shell plates, lb. per sq. in.

t = thickness of shell plate, in weakest course, in.

E = efficiency of longitudinal joint, method of determining which is given in Par. 181, of these Rules

R = inside radius of the weakest course of the shell or drum, in.

FS = factor of safety allowed by these Rules.

379 One year after these rules become effective, boilers of butt and double strap construction shall not be operated without a factor of safety of at least four by the formula, Par. 378. Five years after these rules become effective, the factor of safety shall be at least four and five-tenths. In no case shall the maximum allowable working pressure on old boilers be increased, unless they are being operated at a lesser pressure than would be allowable for new boilers, in which case the changed pressure shall not exceed that allowable for new boilers of the same construction.

380 The lowest factor of safety used for boilers, the shells or drums of which are exposed to the products of combustion, and the longitudinal joints of which are of lap riveted construction, shall be not less than the following:

- $4\frac{1}{4}$ for boilers not over five years old,
- $4\frac{1}{2}$ for boilers over five and not over ten years old,
- $4\frac{3}{4}$ for boilers over ten and not over fifteen years old,
- 5 for boilers over fifteen and not over twenty years old.

For each five years thereafter the factor of safety shall be increased by not less than five-tenths; provided, however, that after a thorough internal and external inspection and a hydrostatic pressure test of one and one-half times the pressure allowed, during which no distress or leakage develops, the pressure allowed may be continued at a factor of safety of five.

The owner or user of such boiler shall prepare the boiler for hydrostatic pressure test by uncovering all riveted joints.

380-a The lowest factor of safety for boilers, the shells or drums of which are not exposed to the products of combustion, and the longitudinal joints of which are of lap riveted construction, shall be not less than the following:

- 4 for boilers not over ten years old,
- $4\frac{1}{4}$ for boilers over ten and not over fifteen years old,
- $4\frac{1}{2}$ for boilers over fifteen and not over twenty years old,
- 5 for boilers over twenty years old.

For each five years thereafter the factor of safety shall be increased by not less than five-tenths; provided, however, that after a thorough internal and external inspection and a hydrostatic pressure test of one and one-half times the pressure allowed, during which no distress or leakage develops, the pressure allowed may be continued at a factor of safety of five.

The owner or user of such boiler shall prepare the boiler for hydrostatic pressure test by uncovering all riveted joints.

381 Second-hand stationary boilers, by which are meant boilers where both the ownership and location are changed, and which are not less than ten years old and which have longitudinal joints of

lap riveted construction, shall have a factor of safety of at least $5\frac{1}{2}$, by the formula of Par. 378, one year after these rules become effective, unless constructed in accordance with the rules contained in Part I, when the factor of safety shall be at least five.

382 *Cast-iron Headers and Mud Drums.* The maximum allowable working pressure on a water tube boiler, the tubes of which are secured to cast-iron or malleable iron headers, or which have cast-iron mud drums, shall not exceed 160 lbs. per sq. in.

383 *Steam Heating Boilers.* The maximum allowable working pressure shall not exceed 15 lbs. per sq. in. on a boiler used exclusively for low pressure steam heating.

384 No pressure shall be allowed on a boiler on which a crack is discovered along the longitudinal riveted joint.

STRENGTH OF MATERIALS

385 *Tensile Strength.* When the tensile strength of steel or wrought-iron shell plates is not known, it shall be taken at 55,000 lbs. per sq. in. for steel, and 45,000 lbs. per sq. in. for wrought-iron. When the tensile strength of cast-iron is not known, it shall be taken as 18,000 lbs. per sq. in.

386 *Strength of Rivets in Shear.* In computing the ultimate strength of rivets in shear the following values in lbs. per sq. in. of the cross-sectional area of the rivet shank shall be used:

Iron rivets in single shear.....	38,000
Iron rivets in double shear.....	76,000
Steel rivets in single shear.....	44,000
Steel rivets in double shear.....	88,000

The cross-sectional area shall be that of the rivet shank after driving.

387 *Crushing Strength of Mild Steel.* The resistance to crushing of mild steel shall be taken at 95,000 lbs. per sq. in. of cross-sectional area.

TABLE 10 — SIZES OF RIVETS BASED ON PLATE THICKNESS

Thickness of plate.....	$\frac{1}{8}$ "	$\frac{9}{16}$ "	$\frac{5}{8}$ "	$\frac{11}{16}$ "	$\frac{3}{4}$ "	$\frac{13}{16}$ "
Diameter of rivet after driving.....	$\frac{11}{16}$ "	$\frac{11}{16}$ "	$\frac{13}{16}$ "	$\frac{3}{4}$ "	$\frac{13}{16}$ "	$\frac{13}{16}$ "
Thickness of plate.....	$\frac{7}{16}$ "	$\frac{15}{16}$ "	$\frac{1}{2}$ "	$\frac{9}{16}$ "	$\frac{5}{8}$"	.....
Diameter of rivet after driving.....	$\frac{11}{16}$ "	$\frac{13}{16}$ "	$\frac{13}{16}$ "	$\frac{11}{16}$ "	$\frac{13}{16}$"	.....

388 *Rivets.* When the diameter of the rivet holes in the longitudinal joints of a boiler is not known, the diameter and cross-sectional area of rivets, after driving may be ascertained from Table 10, or by cutting out one or more rivets in the body of the joint.

SAFETY VALVES FOR POWER BOILERS

389 The safety valve capacity of each boiler shall be such that the safety valve or valves will discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 6 per cent above the maximum allowable working pressure, or more than 6 per cent above the highest pressure to which any valve is set.

390 One or more safety valves on every boiler shall be set at or below the maximum allowable working pressure. The remaining valves may be set within a range of 3 per cent above the maximum allowable working pressure, but the range of setting of all of the valves on a boiler shall not exceed 10 per cent of the highest pressure to which any valve is set.

391 Safety valve capacity may be checked in any one of three different ways, and if found sufficient, additional capacity need not be provided:

- a* By making an accumulation test, by shutting off all other steam discharge outlets from the boiler and forcing the fires to the maximum. The safety valve equipment shall be sufficient to prevent an excess pressure beyond 6 per cent as specified in Par. 389.
- b* By measuring the maximum amount of fuel that can be burned and computing the corresponding evaporative capacity upon the basis of the heating value of the fuel. See Appendix, Pars. 421 to 427.
- c* By determining the maximum evaporative capacity by measuring the feedwater. The sum of the safety valve capacities shall be equal to or greater than the maximum evaporative capacity of the boiler.

392 In case either of the methods outlined in sections *b* or *c* of Par. 391 is employed, the safety valve capacities shall be taken at the maximum values given in Table 8 for spring loaded pop safety valves, or 0.66 times the maximum values given in Table 8, for lever safety valves.

393 When additional valve capacity is required, any valves added shall conform to the requirements in Part I of these rules.

394 No valve of any description shall be placed between the safety valve and the boiler, nor on the discharge pipe between the

safety valve and the atmosphere. When a discharge pipe is used, it shall be not less than the full size of the valve, and the discharge pipe shall be fitted with an open drain to prevent water lodging in the upper part of the safety valve or in the pipe. If a muffler is used on a safety valve it shall have sufficient outlet area to prevent back pressure from interfering with the proper operation and discharge capacity of the valve. The muffler plates or other devices shall be so constructed as to avoid any possibility of restriction of the steam passages due to deposit. When an elbow is placed on a safety valve discharge pipe, it shall be located close to the safety valve outlet or the pipe shall be securely anchored and supported. All safety valve discharges shall be so located or piped as to be carried clear from running boards or working platforms used in controlling the main stop valves of boilers or steam headers.

FITTINGS AND APPLIANCES

395 *Water Glasses and Gage Cocks.* Each steam boiler shall have at least one water glass, the lowest visible part of which shall be not less than 2 in. above the lowest permissible water level.

396 Each boiler shall have three or more gage cocks, located within the range of the visible length of the water glass, when the maximum allowable working pressure exceeds 15 lbs. per sq. in., except when such boiler has two water glasses with independent connections to the boiler, located on the same horizontal line and not less than 2 ft. apart.

Exception should be made where the height of the segment above the tubes on the boiler does not exceed 12 ins.; in which case, at least two gage cocks located within the visible range of the water glass must be used.

397 No connections except for damper regulator, oil burner regulator, feed water regulator, drains, or steam gages, shall be placed on the pipes connecting a water column to a boiler.

398 *Steam Gages.* Each steam boiler shall have a steam gage connected to the steam space or to the water column or to its steam connection. The steam gage shall be connected to a syphon or equivalent device of sufficient capacity to keep the gage tube filled with water and so arranged that the gage cannot be shut off from the boiler except by a cock placed near the gage and provided with a tee or lever handle arranged to be parallel to the pipe in which it is located when the cock is open. Connections to gages shall be of brass, copper or bronze composition.

Each boiler shall be provided with a $\frac{1}{4}$ -in. pipe size valved connection for attaching a test gage when the boiler is in service, so that the accuracy of the boiler steam gage can be ascertained.

399 *Stop Valves.* Each steam outlet from a power boiler (except safety valve connections) shall be fitted with a stop valve located as close as practicable to the boiler.

It is recommended that when two or more boilers are connected to a common steam main, two stop valves, with an ample free blow drain between them be placed in the steam connection between each boiler and the steam main. Also that the discharge of this drain valve be visible to the operator while manipulating the valve and further that the stop valves consist of one automatic non-return valve (set next the boiler) and a second valve of the outside screw and yoke type; or two valves of the outside screw and yoke type may be used.

400 When a stop valve is so located that water can accumulate, ample drains shall be provided.

401 *Bottom Blow-off Pipes.* Each boiler shall have a blow-off pipe fitted with a valve or cock, in direct connection with the lowest water space practicable.

402 When the maximum allowable working pressure exceeds 125 lbs. per sq. in., the blow-off pipe shall be extra heavy from boiler to valve or valves, and shall run full size without reducers or bushings. All fittings between the boiler and valve shall be steel, extra heavy malleable iron or extra heavy cast-iron.

403 When the maximum allowable working pressure exceeds 125 lbs. per sq. in., each bottom blow-off pipe shall be fitted with an extra heavy valve or cock. Preferably two (2) valves, or a valve and a cock should be used on each blow-off in which case such valves, or valve and cock, shall be extra heavy.

404 A bottom blow-off pipe when exposed to direct furnace heat, shall be protected from the products of combustion by fire-brick, a substantial cast-iron removable sleeve, or a covering of non-conducting material.

405 An opening in the boiler setting for a blow-off pipe shall be arranged to provide for free expansion and contraction.

406 *Feed-Piping.* The feed pipe of a steam boiler shall be provided with a check valve near the boiler and a valve or cock between the check valve and the boiler, and when two or more boilers are fed from a common source, there shall also be a valve on the branch to each boiler, between the check valve and the source of supply. When a globe valve is used on a feed pipe, the inlet shall be under the disc of the valve.

The main feed in boilers shall not enter the boiler through the blow-off unless clearly impracticable to introduce it elsewhere.

When a pump, inspirator, or injector is required to supply feedwater to a boiler of over 50 horse power, more than one such mechanical appliance shall be provided.

It is recommended that wherever possible the feed water entering boilers shall be not less than one hundred twenty degrees Fahrenheit.

407 *Lamphrey Fronts.* Each boiler fitted with a Lamphrey boiler furnace mouth protector, or similar appliance, having valves on the pipes connecting them to the boiler, shall have these valves locked or sealed *open*. Such valves, when used, shall be of the straightway type.

HYDROSTATIC PRESSURE TESTS

408 *Test Pressure.* When a hydrostatic test is applied the required test pressure shall be one and one-half times the maximum allowable working pressure. The pressure shall be under proper control so that in no case shall the required test pressure be exceeded by more than 2 per cent.

409 During a hydrostatic test of a boiler, the safety valve or valves shall be removed or each valve disc shall be held to its seat by means of a testing clamp and not by screwing down the compression screw upon the spring.

APPENDIX

EFFICIENCY OF JOINTS

410 *Efficiency of Riveted Joints.* The ratio which the strength of a unit length of a riveted joint has to the same unit length of the solid plate is known as the efficiency of the joint and shall be calculated by the general method illustrated in the following examples:

TS = tensile strength stamped on plate, lb. per sq. in.

t = thickness of plate, in.

b = thickness of butt strap, in.

P = pitch of rivets, in., on row having greatest pitch

d = diameter of rivet after driving, in. = diameter of rivet hole

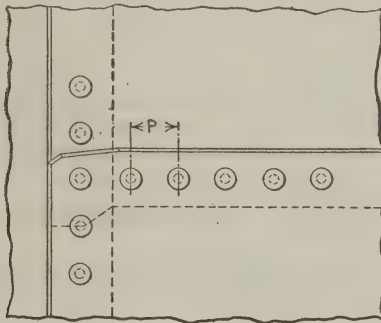


FIG. 21 EXAMPLE OF LAP JOINT, LONGITUDINAL OR CIRCUMFERENTIAL, SINGLE-RIVETED

a = cross-sectional area of rivet after driving, sq. in.

s = shearing strength of rivet in single shear, lb. per sq. in., as given in Par. 16

S = shearing strength of rivet in double shear, lb. per sq. in., as given in Par. 16

c = crushing strength of mild steel, lb. per sq. in., as given in Par. 15

n = number of rivets in single shear in a unit length of joint

N = number of rivets in double shear in a unit length of joint.

411 *Example:* Lap joint, longitudinal or circumferential, single-riveted.

A = strength of solid plate = $P \times t \times TS$

B = strength of plate between rivet holes = $(P-d)t \times TS$

C = shearing strength of one rivet in single shear = $n \times s \times a$

D = crushing strength of plate in front of one rivet = $d \times t \times c$

Divide B , C or D (whichever is the least) by A , and the quotient will be the efficiency of a single-riveted lap joint as shown in Fig. 21.

$TS = 55,000$ lb. per sq. in.

$c = 95,000$ lb. per sq. in.

$t = \frac{1}{4}$ in. = 0.25 in.

$A = 1.625 \times 0.25 \times 55,000 = 22,343$

$P = 1\frac{5}{8}$ in. = 1.625 in.

$B = (1.625 - 0.6875) 0.25 \times 55,000 = 12,890$

$d = \frac{11}{16}$ in. = 0.6875 in.

$C = 1 \times 44,000 \times 0.3712 = 16,332$

$a = 0.3712$ sq. in.

$D = 0.6875 \times 0.25 \times 95,000 = 16,328$

$s = 44,000$ lb. per sq. in.

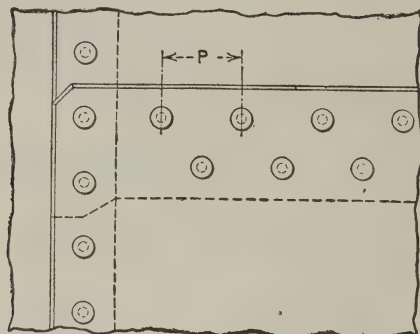


FIG. 22 EXAMPLE OF LAP JOINT, LONGITUDINAL OR CIRCUMFERENTIAL, DOUBLE-RIVETED

$$\frac{12,890 (B)}{22,343 (A)} = 0.576 = \text{efficiency of joint}$$

412 *Example:* Lap joint, longitudinal or circumferential, double-riveted.

A = strength of solid plate = $P \times t \times TS$

B = strength of plate between rivet holes = $(P-d) t \times TS$

C = shearing strength of two rivets in single shear = $n \times s \times a$

D = crushing strength of plate in front of two rivets = $n \times d \times t \times c$

Divide B , C or D (whichever is the least) by A , and the quotient will be the efficiency of a double-riveted lap joint, as shown in Fig. 22.

$TS = 55,000$ lb. per sq. in.

$c = 95,000$ lb. per sq. in.

$t = \frac{5}{16}$ in. = 0.3125 in.

$A = 2.875 \times 0.3125 \times 55,000 = 49,414$

$P = 2\frac{7}{8}$ in. = 2.875 in.

$B = (2.875 - 0.75) 0.3125 \times 55,000 = 36,523$

$d = \frac{3}{4}$ in. = 0.75 in.

$C = 2 \times 44,000 \times 0.4418 = 38,878$

$a = 0.4418$ sq. in.

$D = 2 \times 0.75 \times 0.3125 \times 95,000 = 44,531$

$s = 44,000$ lb. per sq. in.

$$\frac{36,523 (B)}{49,414 (A)} = 0.739 = \text{efficiency of joint}$$

413 *Example:* Butt and double strap joint, double-riveted.

A = strength of solid plate = $P \times t \times TS$

B = strength of plate between rivet holes in the outer row = $(P-d) t \times TS$

C = shearing strength of two rivets in double shear, plus the shearing strength of one rivet in single shear = $N \times S \times a + n \times s \times a$

D = strength of plate between rivet holes in the second row, plus the shearing strength of one rivet in single shear in the outer row = $(P-2d) t \times TS + n \times s \times a$

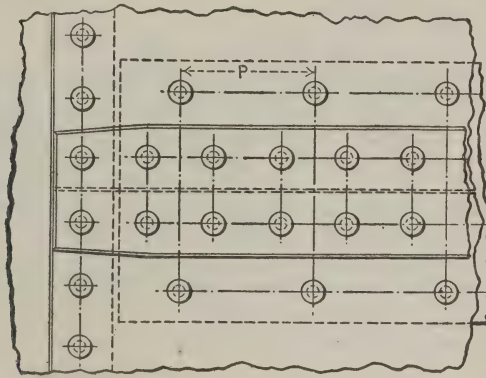


FIG. 23 EXAMPLE OF BUTT AND DOUBLE STRAP JOINT, DOUBLE-RIVETED

E = strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one rivet in the outer row = $(P-2d) t \times TS + d \times b \times c$

F = crushing strength of plate in front of two rivets, plus the crushing strength of butt strap in front of one rivet = $N \times d \times t \times c + n \times d \times b \times c$

G = crushing strength of plate in front of two rivets, plus the shearing strength of one rivet in single shear = $N \times d \times t \times c + n \times s \times a$

H = strength of butt straps between rivet holes in the inner row = $(P-2d) 2b \times TS$. This method of failure is not possible for thicknesses of butt straps required by these Rules and the computation need only be made for old boilers in which thin butt straps have been used. For this reason this method of failure will not be considered in other joints.

Divide B, C, D, E, F, G or H (whichever is the least) by A , and the quotient will

be the efficiency of a butt and double strap joint, double-riveted, as shown in Fig. 23.

$$TS = 55,000 \text{ lb. per sq. in.}$$

$$a = 0.6013 \text{ sq. in.}$$

$$t = \frac{3}{8} \text{ in.} = 0.375 \text{ in.}$$

$$s = 44,000 \text{ lb. per sq. in.}$$

$$b = \frac{5}{16} \text{ in.} = 0.3125 \text{ in.}$$

$$S = 88,000 \text{ lb. per sq. in.}$$

$$P = 4\frac{7}{8} \text{ in.} = 4.875 \text{ in.}$$

$$c = 95,000 \text{ lb. per sq. in.}$$

$$d = \frac{7}{8} \text{ in.} = 0.875 \text{ in.}$$

Number of rivets in single shear in a unit length of joint = 1.

Number of rivets in double shear in a unit length of joint = 2.

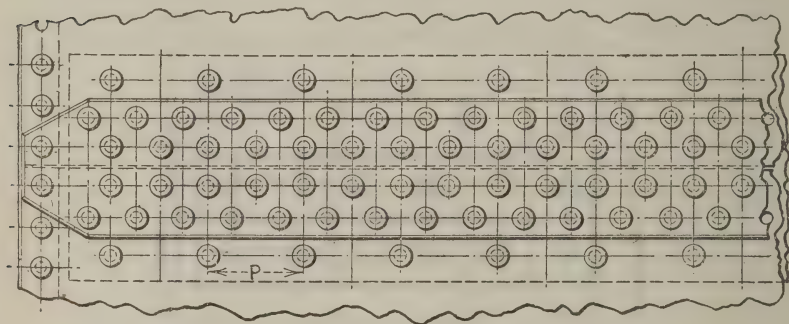


FIG. 24 EXAMPLE OF BUTT AND DOUBLE STRAP JOINT, TRIPLE-RIVETED

$$A = 4.875 \times 0.375 \times 55,000 = 100,547$$

$$B = (4.875 - 0.875) 0.375 \times 55,000 = 82,500$$

$$C = 2 \times 88,000 \times 0.6013 + 1 \times 44,000 \times 0.6013 = 132,286$$

$$D = (4.875 - 2 \times 0.875) 0.375 \times 55,000 + 1 \times 44,000 \times 0.6013 = 90,910$$

$$E = (4.875 - 2 \times 0.875) 0.375 \times 55,000 + 0.875 \times 0.3125 \times 95,000 = 90,429$$

$$F = 2 \times 0.875 \times 0.375 \times 95,000 + 0.875 \times 0.3125 \times 95,000 = 88,320$$

$$G = 2 \times 0.875 \times 0.375 \times 95,000 + 1 \times 44,000 \times 0.6013 = 88,800$$

$$\frac{82,500 (B)}{100,547 (A)} = 0.820 = \text{efficiency of joint}$$

414 *Example:* Butt and double strap joint, triple-riveted.

A = strength of solid plate = $P \times t \times TS$

B = strength of plate between rivet holes in the outer row = $(P - d) t \times TS$

C = shearing strength of four rivets in double shear, plus the shearing strength of one rivet in single shear = $N \times S \times a + n \times s \times a$

D = strength of plate between rivet holes in the second row, plus the shearing strength of one rivet in single shear in the outer row = $(P - 2d) t \times TS + n \times s \times a$

E = strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one rivet in the outer row $= (P - 2d) t \times TS + d \times b \times c$

F = crushing strength of plate in front of four rivets, plus the crushing strength of butt strap in front of one rivet $= N \times d \times t \times c + n \times d \times b \times c$

G = crushing strength of plate in front of four rivets, plus the shearing strength of one rivet in single shear $= N \times d \times t \times c + n \times s \times a$

Divide B , C , D , E , F or G (whichever is the least) by A , and the quotient will be the efficiency of a butt and double strap joint, triple-riveted, as shown in Fig. 24.

$$TS = 55,000 \text{ lb. per sq. in.}$$

$$a = 0.5185 \text{ sq. in.}$$

$$t = \frac{3}{8} \text{ in.} = 0.375 \text{ in.}$$

$$s = 44,000 \text{ lb. per sq. in.}$$

$$b = \frac{5}{16} \text{ in.} = 0.3125 \text{ in.}$$

$$S = 88,000 \text{ lb. per sq. in.}$$

$$P = 6\frac{1}{2} \text{ in.} = 6.5 \text{ in.}$$

$$c = 95,000 \text{ lb. per sq. in.}$$

$$d = \frac{1}{8} \text{ in.} = 0.125 \text{ in.}$$

Number of rivets in single shear in a unit length of joint = 1.

Number of rivets in double shear in a unit length of joint = 4.

$$A = 6.5 \times 0.375 \times 55,000 = 134,062$$

$$B = (6.5 - 0.125) 0.375 \times 55,000 = 117,304$$

$$C = 4 \times 88,000 \times 0.5185 + 1 \times 44,000 \times 0.5185 = 205,326$$

$$D = (6.5 - 2 \times 0.125) 0.375 \times 55,000 + 1 \times 44,000 \times 0.5185 = 123,360$$

$$E = (6.5 - 2 \times 0.125) 0.375 \times 55,000 + 0.125 \times 0.3125 \times 95,000 = 124,667$$

$$F = 4 \times 0.125 \times 0.375 \times 95,000 + 1 \times 0.125 \times 0.3125 \times 95,000 = 139,902$$

$$G = 4 \times 0.125 \times 0.375 \times 95,000 + 1 \times 44,000 \times 0.5185 = 138,595$$

$$\frac{117,304 (B)}{134,062 (A)} = 0.875 = \text{efficiency of joint}$$

415 *Example:* Butt and double strap joint, quadruple-riveted.

A = strength of solid plate $= P \times t \times TS$

B = strength of plate between rivet holes in the outer row $= (P - d) t \times TS$

C = shearing strength of eight rivets in double shear, plus the shearing strength of three rivets in single shear $= N \times S \times a + n \times s \times a$

D = strength of plate between rivet holes in the second row, plus the shearing strength of one rivet in single shear in the outer row $= (P - 2d) t \times TS + 1 \times s \times a$

E = strength of plate between rivet holes in the third row, plus the shearing strength of two rivets in the second row in single shear and one rivet in single shear in the outer row $= (P - 4d) t \times TS + n \times s \times a$

F = strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one rivet in the outer row $= (P - 2d) t \times TS + d \times b \times c$

G = strength of plate between rivet holes in the third row, plus the crushing strength of butt strap in front of two rivets in the second row and one rivet in the outer row $= (P - 4d) t \times TS + n \times d \times b \times c$

H = crushing strength of plate in front of eight rivets, plus the crushing strength of butt strap in front of three rivets $= N \times d \times t \times c + n \times d \times b \times c$

I = crushing strength of plate in front of eight rivets, plus the shearing strength of two rivets in the second row and one rivet in the outer row, in single shear $= N \times d \times t \times c + n \times s \times a$

Divide B, C, D, E, F, G, H or I (whichever is the least) by A , and the quotient will be the efficiency of a butt and double strap joint quadruple-riveted, as shown in Fig. 25.

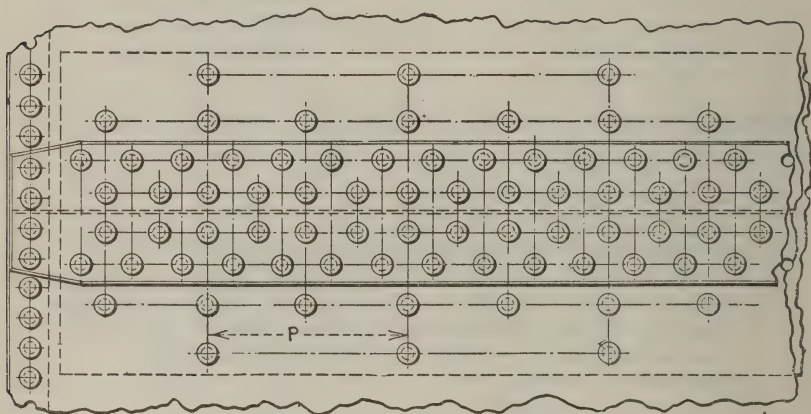


FIG. 25 EXAMPLE OF BUTT AND DOUBLE STRAP JOINT, QUADRUPLE-RIVETED

$$TS = 55,000 \text{ lb. per sq. in.}$$

$$t = \frac{1}{2} \text{ in.} = 0.5 \text{ in.}$$

$$b = \frac{7}{16} \text{ in.} = 0.4375 \text{ in.}$$

$$P = 15 \text{ in.}$$

$$d = \frac{1}{8} \text{ in.} = 0.9375 \text{ in.}$$

$$a = 0.6903 \text{ sq. in.}$$

$$s = 44,000 \text{ lb. per sq. in.}$$

$$S = 88,000 \text{ lb. per sq. in.}$$

$$c = 95,000 \text{ lb. per sq. in.}$$

Number of rivets in single shear in a unit length of joint = 3.

Number of rivets in double shear in a unit length of joint = 8.

$$A = 15 \times 0.5 \times 55,000 = 412,500$$

$$B = (15 - 0.9375) 0.5 \times 55,000 = 386,718$$

$$C = 8 \times 88,000 \times 0.6903 + 3 \times 44,000 \times 0.6903 = 577,090$$

$$D = (15 - 2 \times 0.9375) 0.5 \times 55,000 + 1 \times 44,000 \times 0.6903 = 391,310$$

$$E = (15 - 4 \times 0.9375) 0.5 \times 55,000 + 3 \times 44,000 \times 0.6903 = 400,494$$

$$F = (15 - 2 \times 0.9375) 0.5 \times 55,000 + 0.9375 \times 0.4375 \times 95,000 = 399,902$$

$$G = (15 - 4 \times 0.9375) 0.5 \times 55,000 + 3 \times 0.9375 \times 0.4375 \times 95,000 = 426,269$$

$$H = 8 \times 0.9375 \times 0.5 \times 95,000 + 3 \times 0.9375 \times 0.4375 \times 95,000 = 473,145$$

$$I = 8 \times 0.9375 \times 0.5 \times 95,000 + 3 \times 44,000 \times 0.6903 = 447,369$$

$$\frac{386,718 (B)}{412,500 (A)} = 0.937 = \text{efficiency of joint}$$

416 *Example:* Butt and double strap joint, quintuple-riveted.

A = strength of solid plate = $P \times t \times TS$

B = strength of plate between rivet holes in the outer row = $(P-d) t \times TS$

C = shearing strength of 16 rivets in double shear, plus the shearing strength of seven rivets in single shear = $N \times S \times a + n \times s \times a$

D = strength of plate between rivet holes in the second row, plus the shearing strength of one rivet in single shear in the outer row = $(P-2d) t \times TS + 1 \times s \times a$

E = strength of plate between rivet holes in the third row, plus the shearing strength of two rivets in the second row in single shear and one rivet in single shear in the outer row = $(P-4d) t \times TS + 3 \times s \times a$

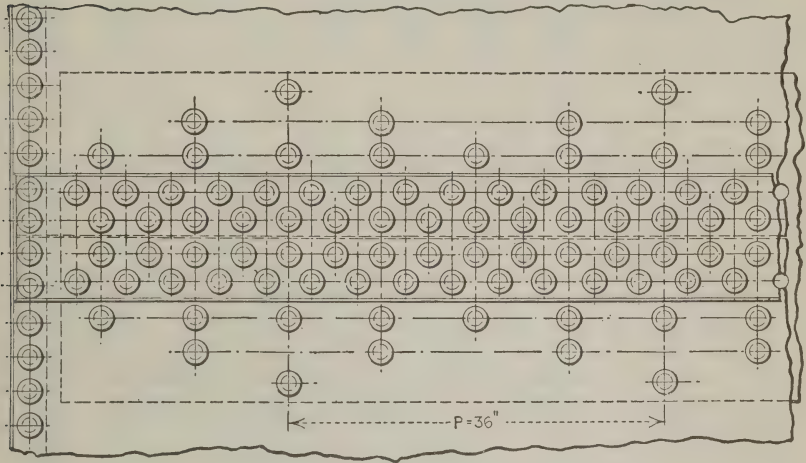


FIG. 26 EXAMPLE OF BUTT AND DOUBLE STRAP JOINT, QUINTUPLE-RIVETED

F = strength of plate between rivet holes in the fourth row, plus the shearing strength of four rivets in the third row, two rivets in the second row and one rivet in the outer row in single shear = $(P-8d) t \times TS + n \times s \times a$

G = strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one rivet in the outer row = $(P-2d) t \times TS + d \times b \times c$

H = strength of plate between rivet holes in the third row, plus the crushing strength of butt strap in front of two rivets in the second row and one rivet in the outer row = $(P-4d) t \times TS + 3 \times d \times b \times c$

I = strength of plate between rivet holes in the fourth row, plus the crushing strength of butt strap in front of four rivets in the third row, two rivets in the second row and one rivet in the outer row = $(P-8d) t \times TS + n \times d \times b \times c$

J = crushing strength of plate in front of 16 rivets, plus the crushing strength of butt strap in front of seven rivets $= N \times d \times t \times c + n \times d \times b \times c$

K = crushing strength of plate in front of 16 rivets, plus the shearing strength of four rivets in the third row, two rivets in the second row and one rivet in the outer row in single shear $= N \times d \times t \times c + n \times s \times a$

Divide $B, C, D, E, F, G, H, I, J$ or K (whichever is the least) by A , and the quotient will be the efficiency of a butt and double strap joint, quintuple-riveted, as shown in Fig. 26 or Fig. 27.

$$TS = 55,000 \text{ lb. per sq. in.}$$

$$t = \frac{3}{4} \text{ in.} = 0.75 \text{ in.}$$

$$b = \frac{1}{2} \text{ in.} = 0.5 \text{ in.}$$

$$P = 36 \text{ in.}$$

$$d = 1\frac{5}{16} \text{ in.} = 1.3125 \text{ in.}$$

$$a = 1.3529 \text{ sq. in.}$$

$$s = 44,000 \text{ lb. per sq. in.}$$

$$S = 88,000 \text{ lb. per sq. in.}$$

$$c = 95,000 \text{ lb. per sq. in.}$$

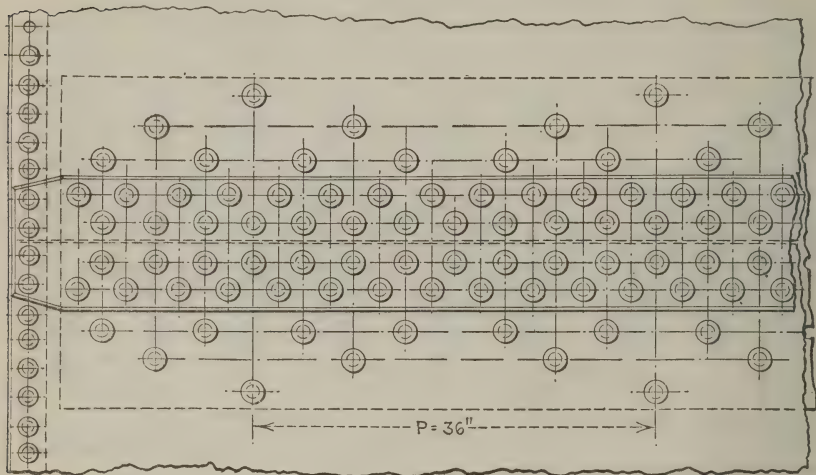


FIG. 27 EXAMPLE OF BUTT AND DOUBLE STRAP JOINT, QUINTUPLE-RIVETED

Number of rivets in single shear in a unit length of joint = 7.

Number of rivets in double shear in a unit length of joint = 16.

$$A = 36 \times 0.75 \times 55,000 = 1,485,000$$

$$B = (36 - 1.3125) 0.75 \times 55,000 = 1,430,860$$

$$C = 16 \times 88,000 \times 1.3529 + 7 \times 44,000 \times 1.3529 = 2,321,576$$

$$D = (36 - 2 \times 1.3125) 0.75 \times 55,000 + 1 \times 44,000 \times 1.3529 = 1,436,246$$

$$E = (36 - 4 \times 1.3125) 0.75 \times 55,000 + 3 \times 44,000 \times 1.3529 = 1,447,020$$

$$F = (36 - 8 \times 1.3125) 0.75 \times 55,000 + 7 \times 44,000 \times 1.3529 = 1,468,568$$

$$G = (36 - 2 \times 1.3125) 0.75 \times 55,000 + 1.3125 \times 0.5 \times 95,000 = 1,439,064$$

$$H = (36 - 4 \times 1.3125) 0.75 \times 55,000 + 3 \times 1.3125 \times 0.5 \times 95,000 = 1,455,472$$

$$I = (36 - 8 \times 1.3125) 0.75 \times 55,000 + 7 \times 1.3125 \times 0.5 \times 95,000 = 1,488,141$$

$$J = 16 \times 1.3125 \times 0.75 \times 95,000 + 7 \times 1.3125 \times 0.5 \times 95,000 = 1,932,266$$

$$K = 16 \times 1.3125 \times 0.75 \times 95,000 + 7 \times 44,000 \times 1.3529 = 1,912,943$$

$$\frac{1,430,860 (B)}{1,485,000 (A)} = 0.963 = \text{efficiency of joint}$$

417 Figs. 28 and 29 illustrate other joints that may be used. The butt and double strap joint with straps of equal width shown in Fig. 28 may be so designed that it will have an efficiency of from 82 to 84 per cent and the saw-tooth joint shown in Fig. 29 so that it will have an efficiency of from 92 to 94 per cent.

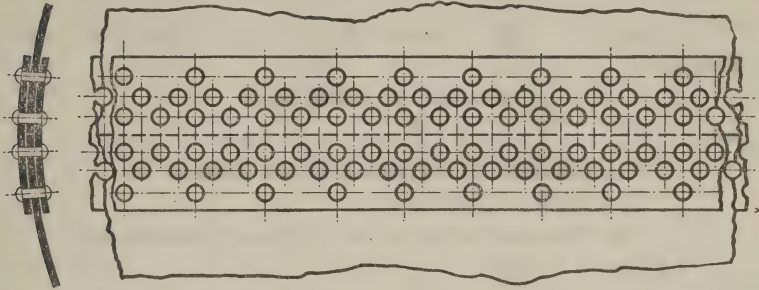


FIG. 28 ILLUSTRATION OF BUTT AND DOUBLE STRAP JOINT WITH STRAPS OF EQUAL WIDTH

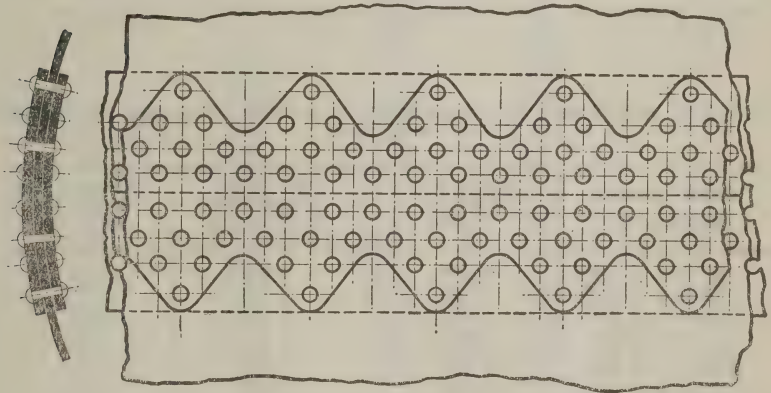


FIG. 29 ILLUSTRATION OF BUTT AND DOUBLE STRAP JOINT OF THE SAW-TOOTH TYPE

BRACED AND STAYED SURFACES

418 The allowable loads based on the net cross-sectional areas of staybolts with V-threads, are computed from the following formulae. The use of Whitworth threads with other pitches is permissible.

The formula for the diameter of a staybolt at the bottom of a V-thread is:

$$D - (P \times 1.732) = d$$

where

D = diameter of staybolt over the threads, in.

P = pitch of threads, in.

d = diameter of staybolt at bottom of threads, in.

1.732 = a constant

When U. S. threads are used, the formula becomes

$$D - (P \times 1.732 \times 0.75) = d$$

Tables 11 and 12 give the allowable loads on net cross-sectional areas for staybolts with V-threads, having 12 and 10 threads per inch.

TABLE 11. ALLOWABLE LOADS ON STAYBOLTS WITH V-THREADS, 12 THREADS PER INCH

Outside Diameter of Staybolts, In.		Diameter at Bottom of Thread, In.	Net Cross- Sectional Area (at Bottom of Thread), Sq. In.	Allowable Load at 7500 Lb. Stress, per Sq. In.
$\frac{3}{4}$	0.7500	0.6057	0.288	2160
$\frac{7}{8}$	0.8125	0.6682	0.351	2632
$\frac{1}{2}$	0.8750	0.7307	0.419	3142
$\frac{1}{2}$	0.9375	0.7932	0.494	3705
1	1.0000	0.8557	0.575	4312
$1\frac{1}{8}$	1.0625	0.9182	0.662	4965
$1\frac{1}{4}$	1.1250	0.9807	0.755	5662
$1\frac{1}{2}$	1.1875	1.0432	0.855	6412
$1\frac{3}{4}$	1.2500	1.1057	0.960	7200
$1\frac{7}{8}$	1.3125	1.1682	1.072	8040
$1\frac{7}{8}$	1.3750	1.2307	1.190	8925
$1\frac{7}{8}$	1.4375	1.2932	1.313	9849
$1\frac{7}{8}$	1.5000	1.3557	1.444	10830

TABLE 12. ALLOWABLE LOADS ON STAYBOLTS WITH V-THREADS, 10 THREADS PER INCH

Outside Diameter of Staybolts, In.		Diameter at Bottom of Thread, In.	Net Cross- Sectional Area (at Bottom of Thread), Sq. In.	Allowable Load at 7500 Lb. Stress per Sq. In.
1¼	1.2500	1.0768	0.911	6832
1½	1.3125	1.1393	1.019	7642
1¾	1.3750	1.2018	1.134	8505
1⅞	1.4375	1.2643	1.255	9412
2	1.5000	1.3268	1.382	10365
2⅛	1.5625	1.3893	1.515	11362
2¼	1.6250	1.4518	1.655	12412

419 Table 13 shows the allowable loads on net cross-sectional areas of round stays or braces.

TABLE 13. ALLOWABLE LOADS ON ROUND BRACES OR STAY RODS

Minimum Diameter of Circular Stay, In.		Net Cross-sectional Area of Stay, in Sq. In.	Allowable Stress, in Lb. per Sq. In., Net Cross-sectional Area		
			6000	8500	9500
			Allowable Load, in Lb., on Net Cross-sectional Area		
1	1.0000	0.7854	4712	6676	7462
1¼	1.0625	0.8866	5320	7536	8423
1½	1.1250	0.9940	5964	8449	9443
1¾	1.1875	1.1075	6645	9414	10521
1⅞	1.2500	1.2272	7363	10431	11658
2	1.3125	1.3530	8118	11501	12854
2⅛	1.3750	1.4849	8909	12622	14107
2¼	1.4375	1.6230	9738	13796	15419
2½	1.5000	1.7671	10603	15020	16787
2⅞	1.5625	1.9175	11505	16298	18216
3	1.6250	2.0739	12443	17628	19702
3¼	1.6875	2.2365	13419	19010	21247
3½	1.7500	2.4053	14432	20445	22852
3¾	1.8125	2.5802	15481	21932	24512
4	1.8750	2.7612	16567	23470	26231
4¼	1.9375	2.9483	17690	25061	28009
4½	2.0000	3.1416	18850	26704	29845
4¾	2.1250	3.5466	21280	30147	33693
5	2.2500	3.9761	23857	33797	37773
5¼	2.3750	4.4301	26580	37656	42086
5½	2.5000	4.9087	29452	41724	46632
5¾	2.6250	5.4119	32471	46001	51413
6	2.7500	5.9396	35638	50487	56426
6¼	2.8750	6.4918	38951	55181	61673
6½	3.0000	7.0686	42412	60083	67152

420 Table 14 gives the net areas of segments of heads for use in computing stays.

TABLE 14. NET AREAS OF SEGMENTS OF HEADS

Height from Tubes to Shell, In.	Diameter of Boiler, In.												
	24	30	36	42	48	54	60	66	72	78	84	90	96
	Area to be stayed, Sq. In.												
8	28	33	37	40	43	47	51	53	55	58	60	63	65
8½	35	41	46	51	55	59	63	66	70	74	76	80	82
9	42	49	56	62	67	72	76	82	86	90	92	95	98
9½	50	58	66	70	80	86	91	96	101	105	111	116	119
10	57	68	77	85	93	99	106	112	117	123	129	132	137
10½	66	78	89	98	107	114	123	131	135	142	147	153	160
11	74	88	100	111	121	130	138	147	155	161	169	174	183
11½	83	99	112	124	137	146	156	165	173	181	189	196	204
12	91	109	125	139	151	163	174	184	194	203	213	219	230
12½	120	138	153	167	180	193	204	216	224	234	243	252	272
13	132	151	168	183	197	211	224	235	247	256	267	279	299
13½	143	164	183	200	216	230	246	258	270	282	293	302	311
14	155	178	199	217	234	250	266	280	294	305	319	331	346
14½	167	192	215	235	254	271	287	303	318	333	345	360	376
15	178	206	231	252	273	291	309	326	343	357	372	386	400
15½	220	247	271	291	312	332	350	368	382	400	417	433	448
16	235	263	289	312	334	355	374	394	411	423	443	457	475
16½	249	281	308	332	357	380	399	420	436	457	475	502	516
17	264	297	326	353	378	402	425	447	467	486	502	536	554
17½	314	345	374	400	426	449	471	494	516	536	554	586	604
18	331	365	396	424	450	476	501	526	552	577	598	631	641
18½	349	384	417	448	476	501	526	552	577	598	631	663	699
19	366	404	439	470	500	529	555	580	604	631	663	699	729
19½	384	424	461	496	528	558	584	613	642	667	699	729	766
20	401	444	483	519	552	583	613	643	675	706	736	766	797
20½	464	505	543	578	613	643	673	703	739	766	797	835	867
21	485	528	568	604	640	670	703	739	766	800	835	867	906
21½	505	551	594	632	669	703	739	766	800	835	867	906	945
22	526	574	618	658	697	734	769	800	835	867	906	945	978
22½	597	643	687	726	765	800	835	867	906	945	978	1018	1051
23	620	668	713	754	796	830	860	890	922	966	1010	1051	1092
23½	642	695	740	784	827	866	904	945	978	1018	1051	1092	1126
24	667	719	768	814	859	897	939	978	1018	1051	1092	1126	1167
24½	689	745	797	843	892	934	975	1018	1051	1092	1126	1167	1202
25	714	771	825	875	922	966	1003	1047	1092	1126	1167	1202	1243
25½	737	798	855	907	956	1003	1047	1092	1126	1167	1202	1243	1279
26	761	824	882	930	987	1035	1083	1126	1167	1202	1243	1279	1321
26½	850	909	968	1024	1073	1120	1167	1202	1243	1279	1321	1360	1400
27	877	939	998	1053	1106	1157	1202	1243	1279	1321	1360	1400	1442
27½	904	968	1030	1089	1145	1195	1243	1279	1321	1360	1400	1442	1480
28	930	997	1060	1120	1177	1232	1279	1321	1360	1400	1442	1480	1523
28½	1028	1092	1157	1211	1270	1321	1360	1400	1442	1480	1523	1561	1605
29	1056	1123	1187	1248	1305	1360	1400	1442	1480	1523	1561	1605	1650
29½	1084	1155	1221	1284	1347	1400	1442	1480	1523	1561	1605	1650	1695
30	1115	1187	1255	1321	1382	1442	1480	1523	1561	1605	1650	1695	1733
30½	1218	1290	1358	1424	1480	1523	1561	1605	1650	1695	1733	1770	1816
31	1252	1324	1394	1459	1516	1561	1605	1650	1695	1733	1770	1816	1856
31½	1286	1359	1433	1496	1553	1605	1650	1695	1733	1770	1816	1856	1900
32	1317	1394	1467	1538	1605	1650	1695	1733	1770	1816	1856	1900	1941
32½	1430	1508	1575	1650	1717	1770	1816	1856	1900	1941	1984	2026	2066
33	1465	1542	1617	1687	1753	1816	1856	1900	1941	1984	2026	2066	2107
33½	1500	1578	1655	1723	1789	1856	1900	1941	1984	2026	2066	2107	2148
34	1536	1617	1695	1763	1829	1895	1941	1984	2026	2066	2107	2148	2189
34½	1654	1735	1816	1884	1950	2016	2066	2107	2148	2189	2230	2271	2312
35	1692	1775	1856	1924	1989	2055	2107	2148	2189	2230	2271	2312	2353
35½	1810	1895	1976	2044	2109	2175	2226	2271	2312	2353	2394	2435	2476
36	1857	1941	2022	2090	2155	2221	2271	2312	2353	2394	2435	2476	2517
36½	1984	2066	2148	2216	2281	2347	2394	2435	2476	2517	2558	2600	2641
37	2026	2107	2189	2257	2322	2388	2435	2476	2517	2558	2600	2641	2682

SAFETY VALVES

421 *Method of Computing Table 8.* The discharge capacity of a safety valve is expressed in equations 2 and 3 as the product of C and H . The discharge capacities are given in Table 8 for each valve size at the pressures shown and are calculated for various valve sizes, pressures and for three different lifts. The discharge capacities are proportional to the lifts, so that intermediate values may be obtained from the Table by interpolation.

C = total weight or volume of fuel of any kind burned per hour at time of maximum forcing, lb. or cu. ft.

H = the heat of combustion, B.t.u. per lb. or cu. ft. of fuel used.

D = diameter of valve seat, in.

L = vertical lift of valve disc, in., measured immediately after the sudden lift due to the pop.

P = absolute boiler pressure or gage pressure plus 14.7 lb. per sq. in.

1100 = the number of B.t.u. required to change a pound of feed water at 100 deg. fahr. into a pound of steam.

The boiler efficiency is assumed as 75 per cent.

The coefficient of discharge, in Napier's formula, is taken as 96 per cent.

$$\frac{C \times H \times 0.75}{1100 \times 3600} = \frac{3.1416 \times D \times L \times 0.707 \times P \times 0.96}{70} \text{ for valve with 45-deg. seat. (1)}$$

$$CH = 160,856 \times P \times D \times L \text{ for valve with bevel seat at 45 deg. (2)}$$

$$CH = 227,487 \times P \times D \times L \text{ for valve with flat seat at 90 deg. (3)}$$

METHOD OF CHECKING THE SAFETY VALVE CAPACITY BY MEASURING THE MAXIMUM AMOUNT OF FUEL THAT CAN BE BURNED

422 The maximum weight of fuel that can be burned is determined by a test. The weight of steam generated per hour is found from the formula:

$$W = \frac{C \times H \times 0.75}{1100} \text{ where}$$

W = weight of steam generated per hour, lb.

C = total weight of fuel burned per hour at time of maximum forcing, lb.

H = the heat of combustion of the fuel, B.t.u. per lb. (see Par. 427).

The sum of the safety valve capacities marked on the valves as provided for in the Rules shall be equal to or greater than the maximum evaporative capacity of the boiler.

Table 8 may be used for determining the number of safety valves required as illustrated in the following examples:

423 *Example 1:* A boiler at the time of maximum forcing uses 2150 lb. of Illinois coal per hour of 12,100 B.t.u. per lb. Boiler pressure, 225 lb. per sq. in. gage.

$$2150 \times 12,100 = CH = 26,015,000$$

Table 8 shows that two 3½-in. bevel seated valves with 0.11 in. lift, or one 3-in. bevel seated valve with 0.10 in. lift and one 3½-in. bevel seated valve with 0.11 in. lift, would discharge the steam generated.

424 *Example 2:* Wood shavings of heat of combustion of 6400 B.t.u. per lb. are burned under a boiler at the maximum rate of 2000 lb. per hour. Boiler pressure, 100 lb. per sq. in. gage.

$$2000 \times 6400 = CH = 12,800,000$$

Table 8 shows that two 3½-in. bevel seated valves with 0.11 in. lift, or one 3-in. bevel seated valve with 0.08 in. lift and one 4-in. bevel seated valve with 0.12 in. lift, would discharge the steam generated.

425 *Example 3:* An oil-fired boiler at maximum forcing uses 1000 lb. of crude oil (Texas) per hour. Boiler pressure, 275 lb. per sq. in. gage.

$$1000 \times 18,500 = CH = 18,500,000$$

Table 8 shows that two 3½-in. bevel seated valves with 0.06 in. lift, or two 3-in. flat seated valves with 0.05 in. lift, or two 2½-in. flat seated valves with 0.06 in. lift, would discharge the steam generated.

426 *Example 4:* A boiler fired with natural gas consumes 3000 cu. ft. per hour. The working pressure is 150 lb. per sq. in. gage.

$$3000 \times 960 = CH = 2,880,000$$

Table 8 shows that two 1¼-in. bevel seated valves with 0.05 in. lift, or two 1-in. flat seated valves with 0.04 in. lift, would discharge the steam generated.

427 For the purpose of checking the safety valve capacity as described in Par. 422, the following values of heats of combustion of various fuels in B.t.u. per lb. or per cu. ft. may be used:

	B. t. u. per lb.
Semi-bituminous coal	14,500
Anthracite	13,700
Screenings	12,500
Coke	13,500
Wood, hard or soft, kiln dried.....	7,700
Wood, hard or soft, air dried.....	6,200
Wood shavings	6,400
Peat, air dried, 25 per cent moisture.....	7,500
Lignite	10,000
Kerosene	20,000
Petroleum, crude oil, Penn.....	20,700
Petroleum, crude oil, Texas.....	18,500
	B. t. u. per cu. ft.
Natural gas	960
Blast furnace gas.....	100
Producer gas	150
Water gas, uncarburetted.....	290

TABLE 15

AMERICAN STANDARD 125-LB. WORKING PRESSURE PER SQ. IN. STANDARD FLANGE FITTINGS, STRAIGHT SIZES (SEE FIG. 30)

	1	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15
A-A																	
Face to face.....	7 71⁄16	8 4	9 10	11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32	33 34	35 36	37 38
Center to face.....	3 31⁄16	4 4	5 5	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17	18 18	19 19
Center to face of long radius els.	5 51⁄16	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17	18 18	19 19	20 20	21 21
Center to face of 45-deg. els.	13 13	14 14	15 15	16 16	17 17	18 18	19 19	20 20	21 21	22 22	23 23	24 24	25 25	26 26	27 27	28 28	29 29
Face to face laterals.....	7 71⁄16	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17	18 18	19 19	20 20	21 21	22 22	23 23
Center to face.....	5 51⁄16	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17	18 18	19 19	20 20	21 21
Center to face of reducer.....	1 1	2 2	3 3	4 4	5 5	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17
Face to face.....	1 1	2 2	3 3	4 4	5 5	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17
Diameter of flange.....	4 4	5 5	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17	18 18	19 19	20 20
Thickness of flange.....	3 3	4 4	5 5	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17	18 18	19 19
Diameter of bolt circle.....	4 4	5 5	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17	18 18	19 19	20 20
No. of bolts.....	4 4	5 5	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17	18 18	19 19	20 20
Diameter of bolts.....	1 1	2 2	3 3	4 4	5 5	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17
Minimum metal thickness of body.....	1 1	2 2	3 3	4 4	5 5	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17

	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
A-A																	
Face to face.....	30 30	32 32	34 34	36 36	38 38	40 40	42 42	44 44	46 46	48 48	50 50	52 52	54 54	56 56	58 58	60 60	62 62
Center to face.....	15 15	16 16	17 17	18 18	19 19	20 20	21 21	22 22	23 23	24 24	25 25	26 26	27 27	28 28	29 29	30 30	31 31
Center to face of long radius els.	24 24	26 26	28 28	30 30	32 32	34 34	36 36	38 38	40 40	42 42	44 44	46 46	48 48	50 50	52 52	54 54	56 56
Center to face of 45-deg. els.	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17	18 18	19 19	20 20	21 21	22 22	23 23	24 24
Face to face laterals.....	30 30	32 32	34 34	36 36	38 38	40 40	42 42	44 44	46 46	48 48	50 50	52 52	54 54	56 56	58 58	60 60	62 62
Center to face.....	15 15	16 16	17 17	18 18	19 19	20 20	21 21	22 22	23 23	24 24	25 25	26 26	27 27	28 28	29 29	30 30	31 31
Center to face of reducer.....	1 1	2 2	3 3	4 4	5 5	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17
Face to face.....	1 1	2 2	3 3	4 4	5 5	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17
Diameter of flange.....	23 23	25 25	27 27	29 29	31 31	33 33	35 35	37 37	39 39	41 41	43 43	45 45	47 47	49 49	51 51	53 53	55 55
Thickness of flange.....	1 1	2 2	3 3	4 4	5 5	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17
Diameter of bolt circle.....	21 21	23 23	25 25	27 27	29 29	31 31	33 33	35 35	37 37	39 39	41 41	43 43	45 45	47 47	49 49	51 51	53 53
No. of bolts.....	16 16	18 18	20 20	22 22	24 24	26 26	28 28	30 30	32 32	34 34	36 36	38 38	40 40	42 42	44 44	46 46	48 48
Diameter of bolts.....	1 1	2 2	3 3	4 4	5 5	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17
Minimum metal thickness of body.....	1 1	2 2	3 3	4 4	5 5	6 6	7 7	8 8	9 9	10 10	11 11	12 12	13 13	14 14	15 15	16 16	17 17

NOTES:—Figures given are for center to face and for face to face finished dimensions. Where necessary manufacturers will make suitable allowances in patterns before casting.

Laterals do not extend beyond the 30-in. size at the present time. Box wrench to be used on bolting for large sizes.

Square head bolts with hexagonal nuts are recommended. 1½ in. diameter and larger stud with a nut at each end is satisfactory.

Hexagonal nuts for pipe sizes 1 in. to 46 in. can be conveniently pulled up with open wrenches of minimum design of heads. Hexagonal nuts for pipe sizes 48 in. to 100 in. can be conveniently pulled up with socket wrenches.

Flanges to be spot bored for nuts for sizes 32 in. to 100 in. inclusive.

TABLE 16

AMERICAN STANDARD, 250-LB. WORKING PRESSURE PER SQ. IN., EXTRA HEAVY FLANGE FITTINGS, STRAIGHT SIZES (SEE FIG. 30)

	1	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15
A-A	8	8½	9	10	11	12	13	14	15	16	17	18	20	21	23	26	30
B	4	4½	5	5½	6	6½	7	7½	8	8½	9	10	10½	11	12	13	15
C	5	5½	6	6½	7	7½	8	8½	9	9½	10	11	12	13	14	15	17
D	6	6½	7	7½	8	8½	9	9½	10	10½	11	12	13	14	15	17	19
E	8½	9	10	11	12	13	14	15	16	17	18	20	21	23	26	30	33
F	6½	7	7½	8	8½	9	9½	10	10½	11	12	13	14	15	17	19	22
G	2	2½	2½	2½	2½	2½	3	3	3	3½	3½	4	4½	5	5½	6½	7½
Face to face.....	5	6	6½	7½	8½	9	10	10½	11	12	13	14	15	16½	17½	20	23
Center to face.....	4½	5	5½	6½	7½	8½	9	10	11	12	13	14	15	16½	17½	20	23
Center to face of long radius ellipse.....	4	4½	5	5½	6	6½	7	7½	8	8½	9	10	11	12	13	15	17
Center to face of 45-deg. ellipse.....	2	2½	2½	2½	2½	2½	3	3	3	3½	3½	4	4½	5	5½	6½	7½
Face to face, laterals.....	8½	9	10	11	12	13	14	15	16	17	18	20	21	23	26	30	33
Center to face, laterals.....	7½	8	8½	9	10	11	12	13	14	15	16	17	18	20	21	23	26
Face to face, reducer.....	2	2½	2½	2½	2½	2½	3	3	3	3½	3½	4	4½	5	5½	6½	7½
Face to face, reducer.....	5	6	6½	7½	8½	9	10	10½	11	12	13	14	15	16½	17½	20	23
Thickness of flange.....	4½	5	5½	6½	7½	8½	9	10	11	12	13	14	15	16½	17½	20	23
Thickness of flange.....	4	4½	5	5½	6	6½	7	7½	8	8½	9	10	11	12	13	15	17
Diameter of bolt circle.....	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	10	11	12	14	16
Number of bolts.....	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Diameter of bolts.....	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½
Minimum metal thickness of body.....	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½	1½

NOTES:—Figures given are for center to face and for face to face finished dimensions. Where necessary manufacturers will make suitable allowances in patterns before casting.

Laterals do not extend beyond the 24 in. size at the present time. Box wrench to be used on bolting for large sizes.

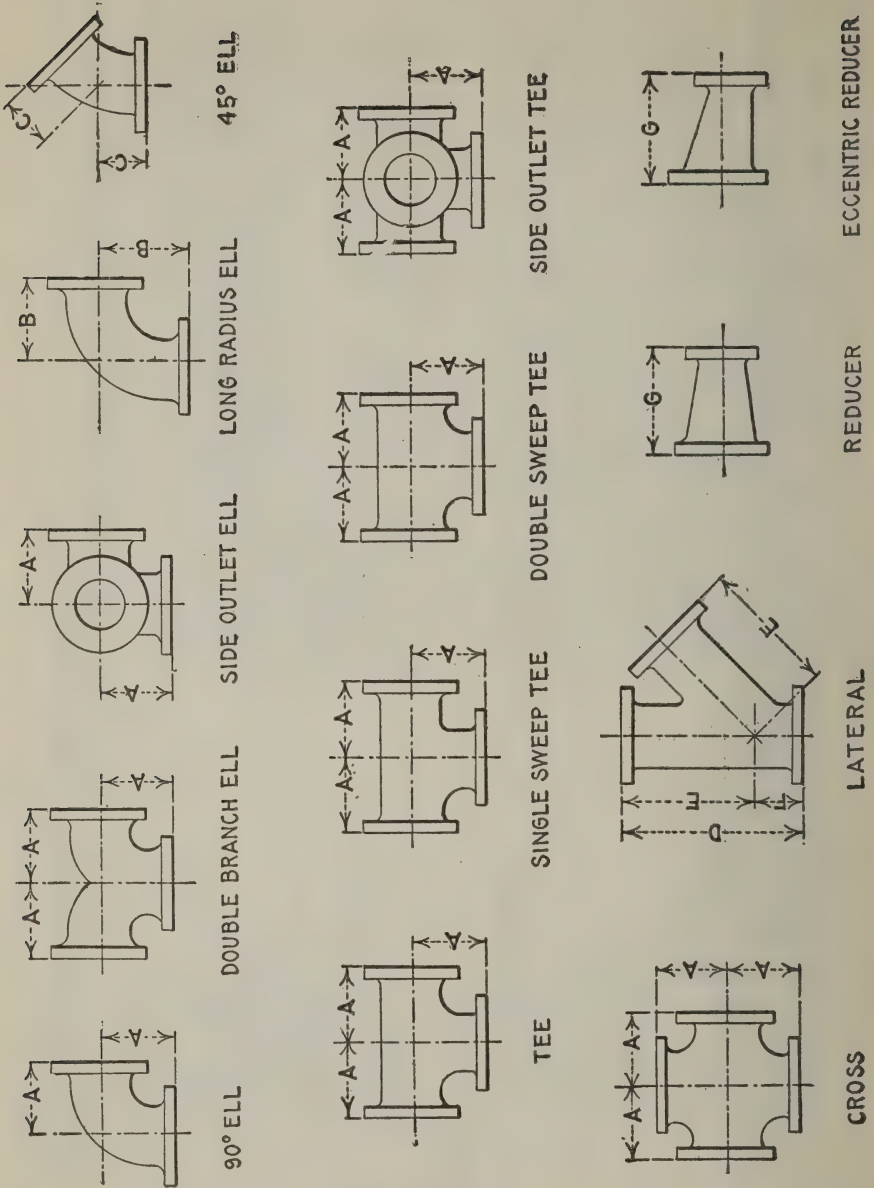
Square head bolts with hexagonal nuts are recommended. 1½ in. diameter and larger stud with a nut at each end is satisfactory.

Hexagonal nuts for pipe sizes 1 in. to 16 in. can be conveniently pulled up with wrenches of minimum design of heads. Hexagonal nuts for pipe sizes 18 in. to 48 in. can be conveniently pulled up with socket wrenches.

Distance between inside edges of bolt holes and raised face to be 1½ in.

Flanges to be spot bored for nuts.

Thickness of flanges given in table includes raised face.



FUSIBLE PLUGS

428 Fusible plugs, if used, shall be filled with tin with a melting point between 400 and 500 deg. fahr.

429 The least diameter of fusible metal shall be not less than $\frac{1}{2}$ in., except for maximum allowable working pressures of over 175 lb. per sq. in. or when it is necessary to place a fusible plug in a tube, in which case the least diameter of fusible metal shall be not less than $\frac{3}{8}$ in.

430 Each boiler may have one or more fusible plugs, located as follows:

- a* In Horizontal Return Tubular Boilers—in the rear head, not less than 2 in. above the upper row of tubes, the measurement to be taken from the line of the upper surface of tubes to the center of the plug, and projecting through the sheet not less than 1 in.
- b* In Horizontal Flue Boilers—in the rear head, on a line with the highest part of the boiler exposed to the products of combustion, and projecting through the sheet not less than 1 in.
- c* In Traction, Portable or Stationary Boilers of the Locomotive Type or Star Water Tube Boilers—in the highest part of the crown sheet, and projecting through the sheet not less than 1 in.
- d* In Vertical Fire-tube Boilers—in an outside tube, not less than one-third the length of the tube above the lower tube sheet.
- e* In Vertical Fire-tube Boilers, Corliss Type—in a tube, not less than one-third the length of the tube above the lower tube sheet.
- f* In Vertical Submerged Tube Boilers—in the upper tube sheet, and projecting through the sheet not less than 1 in.
- g* In Water-tube Boilers, Horizontal Drums, Babcock & Wilcox Type—in the upper drum, not less than 6 in. above the bottom of the drum, over the first pass of the products of combustion, and projecting through the sheet not less than 1 in.
- h* In Stirling Boilers, Standard Type—in the front side of the middle drum, not less than 4 in. above the bottom of the drum, and projecting through the sheet not less than 1 in.

- i* In Stirling Boilers, Superheater Type—in the front drum, not less than 6 in. above the bottom of the drum, exposed to the products of combustion, and projecting through the sheet not less than 1 in.
- j* In Water-tube Boilers, Heine Type—in the front course of the drum, not less than 6 in. above the bottom of the drum, and projecting through the sheet not less than 1 in.
- k* In Robb-Mumford Boilers, Standard Type—in the bottom of the steam and water drum, 24 in. from the center of the rear neck, and projecting through the sheet not less than 1 in.
- l* In Water-tube Boilers, Almy Type—in a tube or fitting exposed to the products of combustion.
- m* In Vertical Boilers, Climax or Hazelton Type—in a tube or center drum not less than one-half the height of the shell, measuring from the lowest circumferential seam.
- n* In Cahall Vertical Water-tube Boilers—in the inner sheet of the top drum, not less than 6 in. above the upper tube sheet, and projecting through the sheet not less than 1 in.
- o* In Wickes Vertical Water-tube Boilers—in the shell of the top drum and not less than 6 in. above the upper tube sheet, and projecting through the sheet not less than 1 in.; so located as to be at the front of the boiler and exposed to the first pass of the products of combustion.
- p* In Scotch Marine Type Boilers—in the combustion chamber top, and projecting through the sheet not less than 1 in.
- q* In Dry Back Scotch Type Boilers—in the rear head, not less than 2 in. above the upper row of tubes, and projecting through the sheet not less than 1 in.
- r* In Economic Type Boilers—in the rear head, above the upper row of tubes.
- s* In Cast-Iron Sectional Heating Boilers—in a section over and in direct contact with the products of combustion in the primary combustion chamber.
- t* In Water-tube Boilers, Worthington Type—in the front side of the steam and water drum, not less than 4 in. above the bottom of the drum, and projecting through the sheet not less than 1 in.
- u* For other types and new designs, fusible plugs shall be placed at the lowest permissible water level, in the direct path of the products of combustion, as near the primary combustion chamber as possible.

INDEX
TO
RULES FOR THE
CONSTRUCTION OF STATIONARY BOILERS
AND FOR ALLOWABLE WORKING
PRESSURES

INDEX TO COMPLETE RULES	117
-------------------------------	-----

INDEX TO COMPLETE RULES

A		PAGE	PAR.
Access and firing doors, power boilers.....	79	327-328	
Access and firing doors, heating boilers.....	86	370	
Adamson furnace	62	242	
Additional safety valves, existing installations.....	91	393	
Adjustment of safety valves for blow down.....	74	281	
Age limit for lap seam boilers.....	89	380	
Allowable load on stay-bolts, table of.....	104	418-419	
loads on circular braces	105	419	
loads on stays, table of.....	105	419	
stress on stays	52	209	
stress on stays and stay-bolts.....	54	220	
working pressure, heating boilers	81	338-340	
working pressure, existing installations	89	378-384	
working pressure, existing installations, heating boilers.....	90	383	
working pressure, power boilers.....	43	179-180	
Altitude gages	85	362	
Angles on h.r.t. boiler heads, 36 in. or less diameter.....	56	225-229	
Area, grate surface, table to determine size of safety valves.....	84	356	
segment, formula for	54	217	
segments of heads to be stayed.....	53	214	
segments, table of	106		
to be stayed in heads.....	53	214-217	
to be stayed in heads having manhole.....	54	218	
Automatic shut-off valves	75	292	
non-return stop valves	76	303	

B

Back pitch of riveted joints.....	44	182	
Bars, steel for boiler parts.....	7	6	
steel, specifications for	19	64- 76	
refined iron, specifications for.....	37	151-163	
Beading of tube ends.....	64	250	
Blow down for safety valves.....	74	281	
Blow-off cock, power boilers	77	309-311	
existing installations	93	401-403	
heating boilers	86	364	
piping, new installations	76	307-313	
piping, existing installations	93	401-405	
piping, heating boilers	86	364	
pipe and fittings	77	311	
Boiler builder's stamps, location of.....	80	333	
builder's stamps, not to be covered.....	80	334	
bushing, for feed pipe connection.....	77	315	
plate steel, specifications for.....	11	23- 39	
to be stamped A.S.M.E. std.....	79	332	
wet bottom, distance from floor line.....	79	326	
wet bottom, distance from floor line (heating boilers).....	86	369	
Braced and stayed surfaces	49	199-233	
Braced and stayed surfaces	104	418	

	PAGE	PAG.
Braces, diameter of pins, area of rivets in and design of crowfeet for....	55	223
made of steel plate	7	5
made of steel plate (gussets).....	56	224
spacing between	51	203
steel bars for	7	6
when welded	7	4
Brackets, to support h.r.t. boilers.....	79	325
Brown furnaces	63	243-244
B.t.u. of various fuels.....	109	427
Butt and double-strap joint		
double riveted	97	413
triple riveted	98	414
quadruple riveted	99	415
quintuple riveted	101	416
Butt straps, tables of minimum thicknesses of.....	9	19
straps, to be rolled or formed.....	45	191
straps, of equal width.....	103	417
straps, saw tooth	103	417
C		
Calking	65	257
Capacity of safety valves		
examples of checking	108	423-426
method of checking	107	422-427
method of checking (existing installations).....	91	391-392
Cast iron (See gray iron castings or malleable castings)		
for headers	64	246
used with superheated steam	8	12
boiler, hydrostatic pressure test of.....	87	372
boiler, maximum pressure allowed on.....	87	374
boiler, section to be tested	87	372
headers, maximum pressure allowed on, existing installations.....	90	382
headers, maximum pressure allowed on, power boilers.....	64	245-247
headers, tested to destruction.....	64	247
Cast steel (See steel)		
Castings, specifications for gray iron.....	26	95-110
specifications for malleable iron.....	29	111-120
specifications for steel	22	77- 94
Channel irons for flat heads.....	50	201
Check valve on feed-pipe	77	317
Check valve on feed-pipe, existing installations.....	93	406
Checking safety valve capacity, method of.....	107	422-427
Checking safety valve capacity, method of, existing installations.....	91	391-392
Circular furnaces and flues.....	61	239-241
Circular manhole opening	65	258
Circumferential joints	44	184-185
Cleanout door in setting	79	327
Cock (See valves, gage cocks, blow-off cocks)		
Combined area of safety valves.....	74	280
Combustion chamber, materials to be used in.....	7	2
Combustion chamber, sling stays.....	60	235-236
Combustion chamber, tube sheets of.....	59	234
Cones, truncated, maximum allowable working pressure on.....	58	231
Connections, flanged	82	246
safety valve	73	277-278
steam gages	75	296
water column	78	320-321
Contraction of steam mains, provision for.....	76	305
Convex and concave heads	49	195
Corrugated furnaces	63	243
Covers, manhole and handhole	7	5

	PAGE	PAGE
Covers, manhole, material	67	262
Cross boxes, material of.....	8	9
Cross pipes connecting steam and water drums, material of.....	8	9
Crown bars and girder stays.....	58	230
Crushing strength of steel plate.....	8	15
Crushing strength of steel plate, existing installations.....	90	387
Crushing strength, applied to joints.....	95	410
Curved surfaces to be stayed.....	58	230

D

Damper regulator, connected to steam space.....	86	365
Damper regulator, connected to water column.....	75	295
Damper regulator, connected to water column, existing installations.....	92	397
Diagonal braces	54	221
stays, stresses in	54	221-222
tube holes in shell or drum.....	47	193
Dial of steam gage	75	297
Diameter of fusible metal in fusible plug.....	113	429
Diameter of rivet holes, old boilers.....	90	388
Direct spring-loaded, safety valve, construction of.....	69	272
Discharge capacity of safety valves.....	68	270-274
Discharge pipe from safety valves.....	73	278-279
Dished heads	49	195-198
Dished heads, corner radius of.....	49	197
Dished heads, with manhole opening.....	49	195
Domes	48	194
Door, access and firing, minimum size of.....	79	327-328
Door, access and firing, minimum size of, heating boilers.....	86	370
Door, frame rings, material of.....	8	13
Door latches	79	328
Doubling plates	50	199
Down-draft boilers, safety valves for.....	85	359
Drains from stop valves.....	76	303-304
from stop valves, existing installations.....	92	400
from superheater	76	306
Drilling rivet holes	65	253-254
Drilling tube holes	64	248-249
Drum or shell, longitudinal joints of (See joints).....	45	187
Drum, material of	7	2- 3

E

Edge of plate to center of rivet.....	44	183
Edges of plates for calking.....	65	257
Edges of tube holes to be removed.....	64	249
Efficiency of ligament, between tube holes.....	46	192
of ligament, between diagonal tube holes.....	47	193
of riveted joints	44	181
of riveted joints, to calculate.....	95-103	410-417
Elbow on escape pipe, from safety valve.....	73	279
Elliptical manhole, size of	65	258
End of feed pipe, to be open.....	77	314
Ends of stay-bolts, to be riveted over.....	50	200
of stays below tubes.....	53	216
of tubes, fire-tube boilers.....	64	250
of tubes, water-tube boilers, and superheaters.....	64	251-252
Equalizer, to support h.r.t. boilers.....	78	324
Escape pipe, from safety valve.....	73	278-279
Escape pipe, from safety valve, existing installations.....	91	394
Escape pipe, from safety valve, heating boilers.....	83	355
Examples of checking safety valve capacities.....	108	423-426
Existing installations	89-93	378-409

	PAGE	PAGE.
Existing installations, steam heating boilers.....	90	383
Expansion of steam mains, provisions for.....	76	305
Extra heavy fittings on blow-off.....	77	310-311
Extra thick tube, for fusible plug.....	113	429
F		
Factors of safety		
for domes when single riveted.....	48	194
existing boilers	89	379
new installations	43	180
second hand boilers	90	381
steel heating boilers	81	340
Feed pipe, ends to be open.....	77	314
Feed pipe, fittings and valves on.....	77	317
Feed piping, power boilers	77	314-318
piping, existing installations	93	406
water discharge	77	315
water, discharge clear of joints.....	77	316
water regulator, connection to.....	75	295
water supply apparatus	78	318
Fire-box steel, for shells, drums.....	7	2
box steel, specifications for.....	11	23- 39
brick casing, for blow-off pipe.....	77	312
tube boiler, manhole in	67	264
tube boiler, thicknesses of tubes of.....	10	22
Firing doors	79	327-328
Fittings and appliances, existing installations.....	92	395-407
Fittings and appliances, heating boilers.....	66	364-368
Fittings and appliances, power boilers.....	76	299-322
Flange fittings, tables of sizes of.....	110-111	
of manhole opening	54	218
steel, for heating boilers.....	81	337
steel, for shells, drums	7	3
steel specifications for	11	23- 39
Flanged connections, heating boilers.....	82	346
Flanged construction for water leg and door frame rings.....	8	13
Flanges, cast iron, thickness of.....	76	299
Flanges, reinforcing, thickness and material of.....	68	268
Flaring of tube ends.....	64	251
Flat surfaces, to be stayed.....	49	199
Flat surfaces, to be stayed between tubes and between tubes and shell....	53	216
Flues, circular, pressure allowed on.....	61	241
Fox furnaces	63	243-244
Fuels, heats of combustion of.....	109	427
Furnace sheets, stamps to be visible on.....	79	331
Furnaces:		
Adamson type	62	242
Brown	63	243
circular flues	61	241
corrugated	63	243
Fox	63	243
internal cylindrical, staying of.....	52	212
Leeds suspension bulb	63	243
material of	7	2
Morison	63	243
plain circular	61	239-240
Purves	63	243
thickness of corrugated or ribbed	64	244
vertical boilers	60	237-238
Fusible plugs	113	428-430
Fusible plugs, location of	113	430

	G	PAGE	PAR.
Gage, altitude		85	362
cocks, existing installations		92	396
cocks, heating boilers		86	367
cocks, power boilers		75	294
inspector's, connection for		75	298
steam and connections, existing installations.....		92	398
steam and connections, heating boilers.....		85	361
steam and connections, power boilers.....		75	296
steam, dial of		75	297
water, glass, existing installations.....		92	395-396
water, glass, heating boilers.....		86	366
water, glass, power boilers.....		75	291-295
Gas fired boilers, safety valves for.....		85	360
Girder stays and crown bars.....		58	230
Globe valve, not to be used on blow-off.....		77	308
Globe valve on feed pipe.....		77	314
Grate surface, table of, for safety valves.....		84	358
Gray iron castings, specifications for.....		26	95-110
Gusset stays, stresses in.....		54	221-224
H			
Handhole covers, material		7	5
Handholes, in h.r.t. boilers.....		67	264
in locomotive type boiler.....		67	265
in vertical fire engine boilers.....		67	267
in vertical fire tube boilers.....		67	266
Headers, cast iron, existing installations.....		90	382
cast iron, new boilers.....		64	245
cast iron, pressure allowed on.....		64	245-247
and pressure parts, material of.....		8	9
Heads, angles for staying upper segments.....		56	225-229
area of segments to be stayed.....		53	213-214
			217
area of segments to be stayed, table for.....		106	420
convex and concave		49	195-198
segments of, area to be stayed.....		53	213-214
			217
stamps to be visible.....		79	331
stiffeners for		50	201
Heating boilers		81	335-377
Heating boilers, existing installations.....		90	383-384
Heating boilers, to which the rules of power boilers shall apply.....		81	335
Heat of combustion of various fuels.....		109	427
Holes for rivets		65	254
for screw stays		52	210
for wash-out, heating boilers.....		82	345
for wash-out, power boilers.....		67	265-267
Horizontal return tubular boilers:			
location of feed-water discharge.....		77	315
longitudinal joints, to be above fire line.....		45	189
manhole below tubes		67	264
maximum length of joint.....		45	190
method of supporting		78	323-324
staying heads of, 36 in or less.....		56	225
water column connections		78	320
Hot water boilers		81	335-377
Hydrostatic pressure test			
of cast iron headers		64	247
heating boilers		87	372-374
old boilers		93	408-409
power boilers		79	329-330
on sections of cast iron boiler.....		87	372

I

	PAGE	PAR.
Inspection at shop, heating boilers.....	87	375
Inspector's test gage connection.....	75	298
Inspirator or injector, used to feed boiler.....	78	318
Insulating material, not to cover boiler stamps.....	80	334
Internal pipe, in steam space.....	75	290
Iron, cast (See cast iron)		
for stay bolts, specifications for.....	34	139-150
rivets, specifications for	31	121-138
rivets, shearing strength of.....	8	16
wrought, stays and stay bolts.....	7	7
wrought, stays and stay bolts, specifications.....	34	139-150
wrought, tensile strength, existing installations.....	90	385
wrought, water leg and door frame rings.....	8	13

J

Joints, back pitch	44	182
Joints, butt and double strap, double riveted, example of.....	97	413
butt and double strap, triple riveted, example of.....	98	414
butt and double strap, quadruple riveted, example of.....	99	415
butt and double strap, quintuple riveted, example of.....	101	416
butt and double strap, required on shell or drum over 36 in. diameter	45	187
calking of	65	257
circumferential	44	184-185
of domes	48	198
efficiency of	44	181
efficiency of, detailed methods of calculation.....	95	410
existing boilers	89	380
heating boilers	82	341-344
lap, double riveted, longitudinal or circumferential, example of.....	96	412
lap crack	90	384
lap riveted, allowed on shell or drum not over 36 in. diameter.....	45	188
lap riveted, allowed on domes.....	48	194
lap single riveted, longitudinal or circumferential, example of.....	96	411
longitudinal	45	187-191
longitudinal lap joints on heating boilers.....	82	341
longitudinal, location of rivet holes on.....	44	183
longitudinal of furnace v.t. boiler to be staybolted.....	60	238
longitudinal of h.r.t. boiler to be above the fire line.....	45	189
longitudinal of h.r.t. boiler to be above the fire line, heating boilers..	86	371
longitudinal, maximum length of	45	190
longitudinal, maximum length of, heating boilers.....	82	342
power boilers	44	181-191
protection of	82	344
welded	45	186

L

Lamphrey fronts, valves on	78	319
Lamphrey fronts, valves on, existing installations.....	93	407
Lap joint crack	90	384
Lap joints:		
length of, heating boilers.....	82	342
length of, power boilers.....	45	190
longitudinal or circumferential, single riveted	96	411
longitudinal or circumferential, double riveted.....	96	412
longitudinal domes	48	194
longitudinal hot water boilers.....	82	343
longitudinal lap crack	90	384
longitudinal, steam heating boilers.....	82	341
Lap welded tubes, specifications for.....	40	164-178
Latches, door	79	328

	PAGE	PAR.
Laying out shell plates, furnace sheets and heads.....	79	331
Leeds suspension bulb furnaces.....	63	243
Length of stays between supports.....	54	220
Ligament between tube holes, efficiency of.....	46	192-193
Load allowed on stay-bolts.....	54	220
Location of A.S.M.E. stamp.....	80	333
of domes.....	48	194
of fusible plugs.....	113	430
Locomotive type boiler, water leg and door frame rings.....	8	13
Longitudinal joints.....	45	187-191
steam heating boilers.....	82	341
hot water boilers.....	82	343
lap crack.....	90	384
on domes.....	48	194
of h.r.t. boilers to be above fire line, heating boilers.....	86	371
of h.r.t. boilers to be above fire line, power boilers.....	45	189
Low pressure steam boiler.....	81	335-377
Lugs, made of steel plate.....	7	5
Lugs, to support h.r.t. boilers.....	78	323-325

M

Main steam pipe, stop valve on.....	76	301-304
Malleable castings, specifications for.....	29	111-120
Manholes.....	65	253-264
below tubes, h.r.t. boiler.....	67	264
below tubes, h.r.t. boiler, staying of.....	54	218
covers, material of.....	67	262
covers, when plate steel.....	7	5
in a dish head.....	49	198
frame, riveting of.....	65	260
frame, proportions of.....	66	261
gaskets, bearing surface of.....	67	263
in any fire tube boiler, over 40 in. diameter.....	67	264
in dome heads.....	67	264
openings, minimum sizes of.....	65	258
plates, material of.....	67	262
reinforcement, material of.....	65	259
reinforcement, on boiler 48 in. diameter or over.....	65	260
Manufacture (See specifications)		
Manufacturer's name, heating boilers.....	87	377
Manufacturer's stamp.....	79	332
Manufacturer's stamp not to be covered.....	80	334
Materials, selection of.....	7	1- 13
Materials, selection of, for heating boilers.....	81	335-337
Maximum allowable working pressure		
braced and stayed surfaces.....	49	199
existing boilers.....	89	378-384
heating boilers.....	81	338-340
shells of power boilers.....	43	179-180
Methods of support.....	78	323-325
Morison furnaces.....	63	243-244
Mud drums, maximum allowable working pressure.....	90	382
Mud drums, material of.....	8	10
Muffler on safety valves.....	73	279

N

Name, manufacturers, on heating boilers.....	87	377
Non-return stop valves, automatic.....	76	303
Nozzles, material of.....	8	12
Nozzles, and fittings.....	76	299
Number of gage cocks.....	75	294
Numbers, serial.....	79	332

O

	PAGE	PAR.
OG flanged construction	8	13
Oil-fired boilers, safety valves for.....	85	360
Openings, flanged connections, heating boilers.....	82	346
Openings, threaded to be reinforced.....	68	268
Outside screw and yoke valves, on steam pipe.....	76	301
Outside screw and yoke valves, on water column.....	75	293

P

Pins in braces, diameter of.....	55	223
Pipes, bottom blow-off and fittings, existing installations.....	93	401-405
bottom blow-off and fittings, heating boilers.....	86	364
bottom blow-off and fittings, power boilers.....	77	308
feed and fittings	77	314-317
in steam space	75	290
main steam, valves on.....	76	301
or nipple, number of threads into fitting.....	76	300
or nipple, number of threads into fitting, table.....	68	268
surface blow-off and fittings.....	76	307
threads, minimum number of	68	268
water column, and fittings.....	78	320
Piping, feed	77	314-318
Pitch of rivets	44	182
of rivets	95	410
of stay-bolts	50	199
of stay-bolts, table	51	203
of stay tubes	59	233
Planing edges of plates.....	65	257
Plate, steel, specifications for.....	11	23- 39
Plates, thickness, in shell or dome after flanging.....	9	18
minimum thickness of in a boiler.....	9	17- 20
minimum thickness of stayed flat surface.....	49	199
Plugs, fusible	113	428-430
Power boilers	7-80	1-384
Power boiler requirements for certain heating boilers.....	81	335
Pressure, allowed on cast iron boilers.....	81	338
allowed on shell or drum, formula for existing installations.....	89	378
allowed on shell or drum, formula for, power boilers.....	43	180
maximum allowable working, on flat surfaces, power boilers.....	49	199
maximum allowable working, old boilers.....	89	378-384
maximum allowable working, old boilers steam heating.....	90	383
maximum allowable working, heating boilers.....	81	338-340
maximum allowable working, on shells, power boilers.....	43	179-180
parts over 2 in., material of.....	8	9
parts of superheaters, material of.....	8	11
Protection of joints	82	344
Pump, to supply feed water.....	78	318
Purves furnaces	63	243

R

Regulators, damper	86	365
Reinforced threaded openings in shell, heads of drums.....	68	268
Relief valves for hot water boilers.....	83	349-350
Reservoirs, on steam mains.....	76	305
Rings, waterleg and door frame, material of.....	8	13
Rivet holes, finish and removal of burrs.....	65	253-254
iron, specifications for	31	121-138
steel, specifications for	15	40- 62
Riveted joints (See joints)		
Riveting	65	253-256

Rivets

	PAGE	PAR.
allowable shearing strength of.....	8	16
allowable shearing strength of, existing installations.....	90	386
existing boilers, diameter of.....	90	388
in braces, area of.....	55	223
in shear on lugs or brackets.....	79	325
in shear on manhole frames.....	65	260
length of and heads for.....	65	255
machine driven.....	65	256
material of.....	8	8
to completely fill rivet holes.....	65	255
Rolling, ends of shell plates.....	45	191

S

Safety, factor of

for existing boilers.....	89	379
for existing lap joint boilers.....	89	380
for power boilers.....	43	180
for steel heating boilers.....	81	340

Safety valves

additional on existing installations.....	91	393
blow-down adjustment.....	74	281
capacity, method of checking.....	107	422-427
connections, existing boilers.....	91	394
connections, heating boilers.....	83	347
connections, power boilers.....	73-74	276-278
		280
		289-290
construction.....	74	282-287
construction, heating boilers.....	84	356-358
discharge capacity, existing boilers.....	91	391-392
discharge capacity, power boilers.....	68	270-274
discharge capacity, table of.....	70-72	
escape pipe for.....	73	278
escape pipe for, existing installations.....	91	394
escape pipe for, heating boilers.....	83	355
for down draft boilers.....	85	359
for existing installations.....	91	389-394
for heating boilers.....	83	347-360
for oil and gas fired boilers.....	85	360
formula for.....	107	421
formula for heating boilers.....	83-84	351-358
method of computing and checking.....	107	421-427
method of computing and checking, existing installations.....	91	391-392
muffler on.....	73	279
muffler on, existing installations.....	91	394
power boilers.....	68	269-290
required on boiler.....	68	269
required on boiler, existing installations.....	91	390
required on heating boilers.....	83	348
seats of.....	69	272
seats of heating boilers.....	84	357
setting of.....	68	271-281
setting of, existing installations.....	91	390
setting of, existing installations, heating boilers.....	83	348
size limits, heating boilers.....	83	351
size limits, power boilers.....	69	272
stamping of.....	69	273
stamping of, heating boilers.....	84	357
superheater.....	74	288-289
table of, for heating boilers.....	84	356
test of.....	73	275
testing of existing installations.....	91	391

	PAGE	PAR.
Saw-tooth type of butt and double strap joint.....	103	417
Screwed stays, supporting of.....	54	219
Seamless tubes, specifications for.....	40	164-178
Seats of safety valves	69	272
Second hand boilers	90	381
Sections of cast iron, to be tested.....	87	372
Segment, area to be stayed.....	53	214-217
of head, to be stayed.....	53	213
method of determining net areas, water tube boilers.....	53	215
Segments, table of	106	420
Selection of material	7	1- 13
Serial number	79	332
Setting of safety valves.....	68	271
of safety valves, existing installations.....	91	390
of safety valves, existing installations, heating boilers.....	83	348
Setting, method of, wet bottom heating boilers.....	86	369
Setting, method of, wet bottom power boilers.....	79	326
Settings, heating boilers	86	369-371
Settings, power boilers	78	323-328
Shearing strength of rivets	8	16
Shearing strength of rivets, existing installations.....	90	386
Shell or drum, longitudinal joints of.....	45	187-190
or drum, to determind allowable pressure on, new boilers.....	43	180
or drum, to determine allowable pressure on, existing boilers.....	89	378
plate, thickness of	9	17- 20
Shut-off valves on water column pipes.....	75	293
Shop inspection of heating boilers.....	87	375
Sizes of flanged fittings, tables.....	110-111	
Sling stays	60	235-236
Specifications for gray iron castings.....	26	95-110
lap welded and seamless boiler tubes.....	40	164-178
material, heating boilers	81	336
malleable castings	29	111-120
plate steel	11	23- 39
refined wrought iron bars.....	37	151-153
rivet iron	31	121-138
rivet steel	15	40- 62
stay bolt iron	34	139-150
stay bolt steel	19	63
steel bars	19	64- 76
steel castings	22	77- 94
Stamping boilers A.S.M.E. std.....	79	332
Stamps, A.S.M.E. std., location of.....	80	333
Stamps, not to be covered by insulation.....	80	334
Stamps, to be visible on shell plates, furnaces sheets and heads.....	79	331
Stay bolted surface, to compute allowable pressure on.....	49	199
Stay bolts		
adjacent to edges of stay-bolted surface.....	51	205
adjacent to furnace door or other opening.....	52	206
adjacent to furnace joint, v.t. boiler.....	60	238
diameter of, how measured.....	52	208
ends of	50	200-202
.....		211
holes for	52	210
iron, specifications for	34	139-150
material of	7	7
maximum allowable stress on.....	54	220
pitch of	49	199-204
steel, specifications for	19	63
tables of allowable load on.....	104	418-419
Stayed and braced surfaces	49	199-233
Stayed flat surface	49	199

	PAGE	PAGE
Staying heads	55	222
heads h.r.t. boiler 36 in. or less diameter	56	225-229
dished heads	49	196
furnaces	52	212
segments of heads	53	213
segments of heads with manhole opening	54	218
Stay-rods, ends riveted over, to be supported	54	219
Stay-tubes	58	232-233
Stays, crown bars and girders	58	230
cross sectional area in calculating	52	209
diagonal and gusset, stresses in	54	221-222
maximum allowable stress	54	220
slings	60	235-236
tables of allowable load on	104	418-419
screwed, supporting of	54	219
upset for threading	52	211
and stay-bolts, allowable stress on	54	220
and stay-bolts, table of allowable stress on	104	418-419
Steam gage and connections, existing installations	92	398
gage and connections, heating boilers	85	361
gage and connections, power boilers	75	296-298
heating boilers, existing installations	90	383-384
mains	76	305
mains, reservoirs on	76	305
outlets	76	301
outlets, existing installations	92	399
Steel bars, for boiler parts	7	6
castings, specifications for	22	77- 94
crushing strength of plate	8	15
for rivets, specifications for	15	40- 62
for stay-bolts, specifications for	19	63
plates exposed to fire	7	2
plates when firebox quality not specified	7	3
plates, shearing strength of	8	16
stays and stay-bolts	49	199-212
tensile strength of, existing installations	90	385
wrought or cast, for boiler and superheater parts	8	11
plate, crushing strength of	8	15
plate, heating boilers	81	385-384
plate, specifications for	11	23- 39
plate, tensile strength of	8	14
Stop valves (See valves)		
Straps, butt, of equal width	103	417
Straps, butt, saw-tooth	103	417
Superheater drains	76	306
safety valve on	74	288-289
tubes and nipples	64	251-252
Superheaters and mountings, material for	8	11- 12
Support, methods of, for boilers	78	323-326
Support of stays, ends riveted over	54	219
Surface blow-off	76	307
Suspended type of setting h.r.t. boilers	78	324

T

Table of angles for staying heads	56	225
constants for pitch of stay tubes	59	233
discharge capacities of spring-loaded safety valves	69-70	
flange fittings, standard	110	
flange fittings, extra heavy	111	

	PAGE	PAR.
Table of maximum allowable pitch of stay-bolts, ends riveted.....	51	204
maximum allowable stresses for stays and stay-bolts.....	54	220
minimum pipe threads for boiler connections.....	68	268
net areas of segments.....	106	420
round braces or stay rods allowable loads.....	105	419
sizes of safety valves, heating boilers.....	84	358
sizes of rivets, existing boilers.....	90	388
stay-bolts, allowable loads, 12 threads per inch.....	104	418
stay-bolts, allowable loads, 10 threads per inch.....	105	418
thickness of butt straps.....	9	19
Tensile strength of steel or wrought iron, existing installations.....	90	385
Tensile strength of steel plate.....	8	14
Test, hydrostatic, of existing installations.....	93	408-409
hydrostatic, of heating boilers.....	87	372-375
hydrostatic, of power boilers.....	79	329-330
of safety valve, existing installations.....	91	391
of safety valve, power boilers.....	73	275
of steam gage.....	75	298
gage, connection for.....	75	298
Thermometers on hot water boilers.....	86	363
Thickness of corrugated or ribbed furnace.....	64	244
required for boiler plates.....	9	17
required for butt straps.....	9	19
required for dome plates after flanging.....	9	18
required for shell plates.....	9	18
required for tube sheets.....	9	20
required for tubes.....	10	21- 22
Threaded openings.....	68	268
Threads, pipe or nipple into fitting.....	76	300
Threads, table.....	68	268
Tin, for fusible plugs.....	113	428
Truncated cones, maximum allowable working pressure on.....	58	231
Tube ends, fire tube boiler.....	64	250
ends, water tube boilers and superheaters.....	64	252
for fusible plug.....	113	429
heads, upper, staying segments of by steel angles.....	56	225-229
heads, of water tube boilers.....	53	215
holes and ends.....	64	248-252
holes, diagonal, in shell or drum.....	47	193
holes in shell or drum.....	46	192
holes, sharp edges to be removed.....	64	249
sheets of combustion chambers.....	59	234
sheets, minimum thickness of.....	9	20
sheets, space allowed unstayed between tubes and between tubes and shell	53	216
Tubes for fire-tube boilers, thicknesses of.....	10	22
for water-tube boilers, thicknesses of.....	10	21
lapwelded and seamless, specifications for.....	40	164-178
required thickness.....	10	21- 22
stay.....	58	232-233

V

Valves, automatic, on water glass.....	75	292
automatic non-return stop.....	76	303
extra heavy, on bottom blow-off.....	77	311
extra heavy, on main steam pipe.....	76	302
globe, not to be used on blow-off.....	77	308
globe, on feed pipe.....	77	314
on bottom blow-off.....	77	308-311
on bottom blow-off, existing installations.....	93	401-403
on every steam outlet.....	76	301
on feed pipe.....	77	317
on feed pipe, existing installations.....	93	406

	PAGE	PAR.
Valves, on Lamphrey fronts.....	78	319
on Lamphrey fronts, existing installations.....	93	407
outside screw and yoke type, on steam pipes.....	76	301
outside screw and yoke type, on water column.....	75	293
safety [See safety valves)		
stop	76	301-304
stop, drains for	76	303-304
stop, existing installations	92	399
stop, existing installations, drains.....	92	400
Vertical boilers, furnaces of.....	60	237-238
fire-tube boiler, manhole in.....	67	264
fire-tube boiler, waterleg and door frame ring.....	8	13

W

Washout holes, hot water boilers.....	82	345
Washout holes, power boilers.....	67	265-267
Water column and connections, existing installations.....	92	397
column and connections, heating boilers.....	86	368
column and connections, power boilers.....	75	295
column and connections, power boilers.....	78	320-322
glass and gage cocks, location of, power boilers.....	75	291-292
glass, automatic valves not allowed.....	75	292
glasses, existing installations	92	395
glasses, heating boilers	86	366
relief valves for hot water boilers.....	83	349-350
Waterleg rings, material of	8	13
Water tube boilers		
cast iron for headers of.....	64	246
flaring of tube ends	64	251
thicknesses of tubes of.....	10	21
wrought or cast steel parts of.....	8	9
Welded joints	45	186
Welded stays	52	209
Wet bottom boilers, height from floor line.....	79	326
Wet bottom boilers, height from floor line, heating boilers.....	86	369
Working pressure, maximum allowable		
existing installations	89	378-384
power boilers	43	179-180
steam and hot water boilers.....	81	338-340
Wrought iron (See iron)		
Wrought steel (See steel)		

